POWER PLANT ENGINEERING

Established Over 30 Years

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Contents of this Issue

Page

Bettendorf Co. Completes Modern Power House. By C. F. Bielenberg. Illustrated.....626

High Pressure Turbines for Industrial Plants. By Francis Hodgkinson. Illustrated.....630

Automatic Combustion Control Necessary for Economy. By J. W. Pecler.....634

Design and Operation of Pulverizer Feeders. By S. C. Martin. Illustrated.....635

Divided Counsel Costs Money. By Morgan G. Farrell....637

Power Development in the Great Lakes Area. Illustrated..640

Importance of Heat Transfer in Oil Heaters. By T. J. Ess. Illustrated.....643

G. E. Produces Two Methods for Obtaining Ductile Welds 646

Duties of a Diesel Engineer. By M. L. Black.....647

Modern Methods of Winding Armatures. By Charles G. Green. Illustrated.....648

Simultaneous Loading of 2-Voltage Transformers. By E. P. Wimmer. Illustrated.....651

Power for the Western Electric Co. at Kearny. Illustrated.653

Propeller Type Turbines May Have Too Great Suction Head. Illustrated.....657

Hydraulic Governor Balanced in All Positions. Illustrated.658

Associated Power Companies Offer to Lease Muscle Shoals. 658

New Conveyor Tests Are Successful. Illustrated.....659

The Diphenyl Oxide Boiler.....660

Oxy-Acetylene Welding in Refrigeration Work. By Charles H. Herter.....661

Commercial Stocks of Anthracite and Bituminous Coal....662

Department of Commerce Analyzes Stoker Sales.....662

Letters Direct from the Plant: Application of Centrifugal Pump Chart Limited. Available Draft Limits Combustion Rates. Cast-iron Sleeve Protects Fire Tubes. Adopting the Metric System. Power Salesman Has Valuable Suggestions. Illustrated.....663

Questions and Answers: Thermocouple Used for Coal Storage Temperature. Figuring the Size of a Crankpin. Maximum CO_2 Obtainable from Fuels. Illustrated.....666

Editorial Comment: Benefits of High Pressures Now Applicable to Industrial Plants. Spring Is a Time of Preparation. Apprentice Systems and Industry. Whether It's Frogs or Power Plants, Ask Uncle Sam. The Function of History. Will 1926 Be a Year of Mergers?....668

N. E. L. A. Convention Opens with Thousands in Attendance.....670

Dual Thermostat Gives Close Temperature Control. Illustrated.....670

Flywheel Type of Alternator. Illustrated.....671

Simple Device Protects Conduit Threads.....671

Expansion Joint Provided in Beco Baffle Wall. Illustrated.672

Power Specialty Co. Acquires Aero Pulverizer Co......672

A. S. M. E. Announces Program for San Francisco Meeting.....672

Death of R. Sanford Riley Surprise to Many.....673

Carl Hering Dies Suddenly.....673

News Notes.....673

Books and Catalogs.....675

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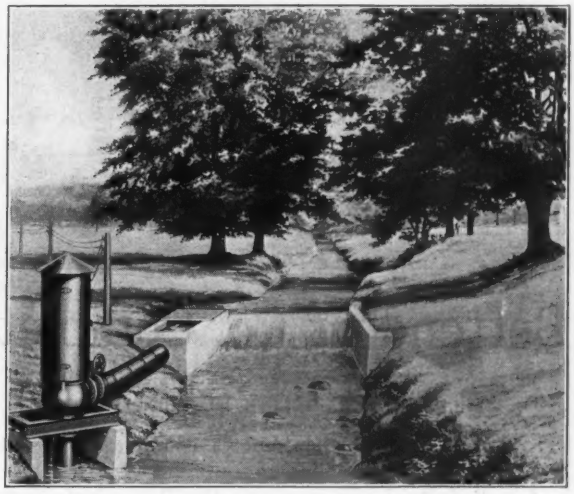


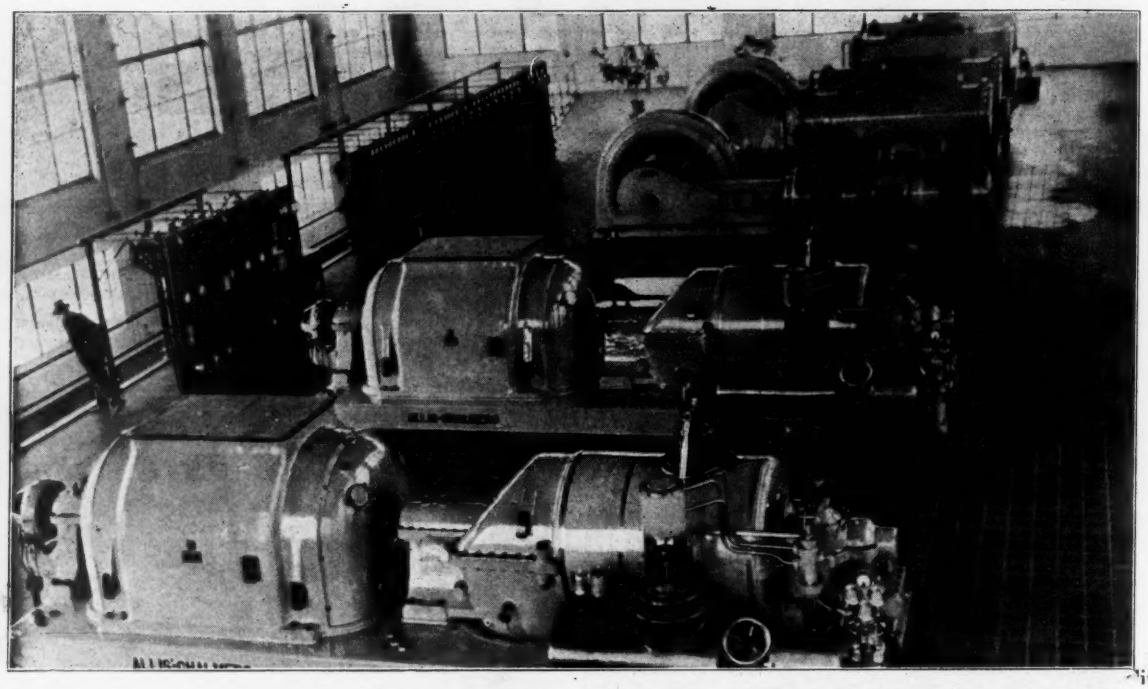
Gulliver's Travels

IF GULLIVER in his wanderings through Lilliputia had barked his shins against one of the stubby little poles in the above picture his natural curiosity would have no doubt prompted him to follow the transmission line to its termination.

While bathing his bruised shins in the cool brook he would have gazed at the odd contraption with mild interest wondering the while at the ingenuity of the little people in caging a blue bottle fly big enough to make the hum which apparently came from the inside.

If, however, Gulliver had been a modern engineer he would have carefully opened the door, changed all the governor weights, lifted up the generator brushes to see them spark, poked his knife blade in the plug fuses, loosened up all the bolts and then turned the thing upside down to discover the type of runner used. Having satisfied his curiosity he would have stood back, looked thoughtful, pulled out his slide rule and muttered—"Kw times the elevation plus four times the square of 2g divided by the cube root of temperature is equal to eighteen thousand times the allowable draft head of a propeller type runner." Nodding his head in approval at the little men's work he would continue on his way.

All of which would have been his way of showing that he was up-to-date and had read the article on page 657 dealing with the importance of draft head in connection with pitting of hydraulic turbine runners.



Bettendorf Co. Completes Modern Power House

WASTE HEAT BOILERS SUPPLY SUPERHEATED STEAM TO TURBO-GENERATORS, WHICH FURNISH POWER FOR COMPLETE ELECTRIC, PNEUMATIC AND HYDRAULIC SERVICE. BY C. F. BIELENBERG*

REALIZING the importance of an adequate and dependable supply of power to meet industrial requirements, the Bettendorf Company, builders of railway freight cars, recently completed a new power house at their Bettendorf, Iowa, plant. Planned entirely by architects and engineers of the company, the design is modern in every detail, laid out to meet present and future shop demands.

For many years these shops were served by a combination of purchased and generated power. Steam-driven compressors, pumps and engine-generator sets exhausted to low and mixed pressure turbo generators, power requirements above those met by the available steam being supplied at 2300 volts by the Peoples Light Co. of Davenport.

When, in 1924, it was decided to build a new power plant, many plans and equipment combinations were studied, before deciding to build an entirely new building and use new equipment. Poor soil conditions for foundations, old and obsolete equipment, difficulty in keeping the old machinery running while erecting an addition to the building and the great distance that steam, from the waste heat boilers, had to travel were the deciding factors in abandoning the old plant.

Incorporated in the new building of steel, brick and concrete construction with terra cotta trimmings, are some interesting features. Designed by Ralph Bowling, architect, and constructed under the supervision of A. C. Drew, civil engineer, the building has a lighting surface of 80 per cent and a maximum ventilation surface of 60 per cent of the total wall area. Due to the heat and humidity a gypsum roof was used, designed for a live load of 40 lb. per sq. ft. This roof is 3½ in. thick, made up of pure gypsum mixed with white pine shavings. The mixture is poured on wall board laid directly on the truss purlins and being quite porous, is waterproofed by a four-ply Barber asphalt roof covering.

Concrete walls 24 in. thick are used below ground and the basement floor is of waterproofed concrete. Above this the reinforced concrete operating floor, from 7 to 10 in. in thickness including the red tile covering, is designed to carry a live load varying from 75 to 150 lb. per sq. ft. To eliminate the many columns necessary to support this floor, a new type construction, utilizing the machine foundations, was used. Ledges on foundations were covered with 3 in. of pressed cork and the floor concrete poured directly on this. Foundations thus act as columns, vibrations of the machinery being absorbed by the cork and not transferred to the floor and walls.

WASTE HEAT BOILERS SUPPLY SUPERHEATED STEAM

Steam is supplied by two boiler plants through 10-in. mains, and passes through two separators, placed in series, before reaching the turbines. Three inches of insulation are used to prevent radiation while the expansion in the line is taken care of by bends. These lines together with all other outgoing pipes are carried north through three tunnels to a larger steel and concrete tunnel 7 ft. 3 in. high by 7 ft. 3 in. wide which runs parallel with the north side of the building. Electric cables are carried separately in an older and smaller tunnel north of the new one.

After reaching the main tunnel the two steam lines

*Electrical Engineer, Bettendorf Co., Bettendorf, Ia.

separate going to their respective boiler plants approximately 2000 ft. apart, the new engine room being located midway between the two. Four 250-hp. and two 300-hp. Wickes boilers with chain grate stokers, over head bunkers and weigh larries supply 140 lb. saturated steam at the old plant. Eventually this will be abandoned and a modern boiler room constructed near the new engine room.

Steam from the direct fired boilers is supplemented by 140 lb. 100 deg. superheat steam furnished by six 257-hp. Freyn Engineering Co. fire-tube, single pass, horizontal boilers receiving waste heat from six 25-t. oil fired open hearth steel furnaces. The boilers were designed and furnished by Freyn Engineering Co., consulting engineers on the waste heat boiler plant, who also specified and furnished the auxiliary and water-treating equipment. Boiler feed water is treated by a 310,000-gal. zeolite water softener furnished by the Permutit Company, after passing through a Dorr 30-ft. settling basin. Two turbine-driven, single-stage centrifugal boiler feed units of the Westco-Chippewa Pump Co. supply 200 g.p.m. each against a pressure of 180 lb., the water being measured by a Venturi meter and controlled at the boilers by Victor feed-water regulators. Each boiler is equipped with a 12,500-cu. ft. per min. induced draft fan supplied by the Green Fuel Economizer Co. and driven by a 40-hp. variable speed Westinghouse motor.

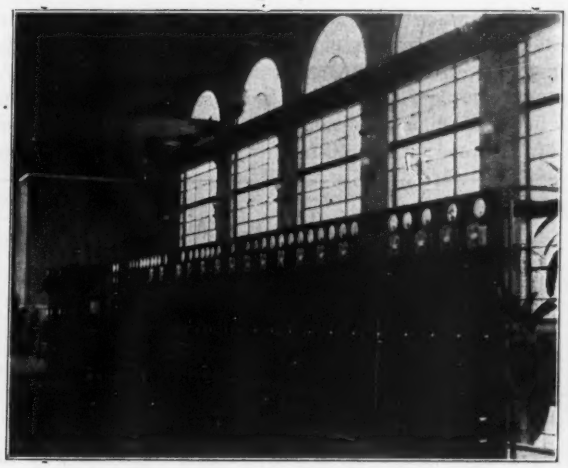


FIG. 2. BOTH SWITCHBOARDS ARE PLACED IN PLAIN VIEW OF TURBINE OPERATOR

AVERAGE RESULTS OBTAINED FROM TESTS ON WASTE HEAT BOILERS

Test	1	2	3	4
CO_2 content of waste gas, per cent	10.2	8.9	8.95	9.28
Weight of waste gases per hr., lb.	56,500	53,500	54,500	47,200
Temperature gases to boilers, deg. F.	1,350	1,230	1,188	1,192
Temperature of gases leaving boiler, deg. F.	530	465	490	442
Draft loss through boiler, in.	1.7	1.52	1.58	1.04
Gross boiler horsepower	342	307	285	264
Brake horsepower at fan	15.4	12.0	12.85	7.03
Per cent rating	110	99.5	93.0	86.0
Boiler efficiency, per cent	63.5	68.0	62.0	66.5

Auxiliary oil burners designed by P. W. Peck, superintendent of power, are provided for emergency operation, the arrangement of the equipment being shown in Fig. 1. Four eight-hour tests at various rating have been made on the installation, a summary of results being given in the table.

Furnace: Basic open hearth, rated capacity, 25 t., burning oil.

Boiler: Freyn Engineering Co. high-velocity, single-pass, fire-tube type, for 160 lb. pressure. Heating surface, 3005 sq. ft., shell, 78 in. by 20 ft.

All equipment in the new plant is motor driven, Fig. 3 showing the general arrangement with provision for the installation of an additional compressor and turbo-

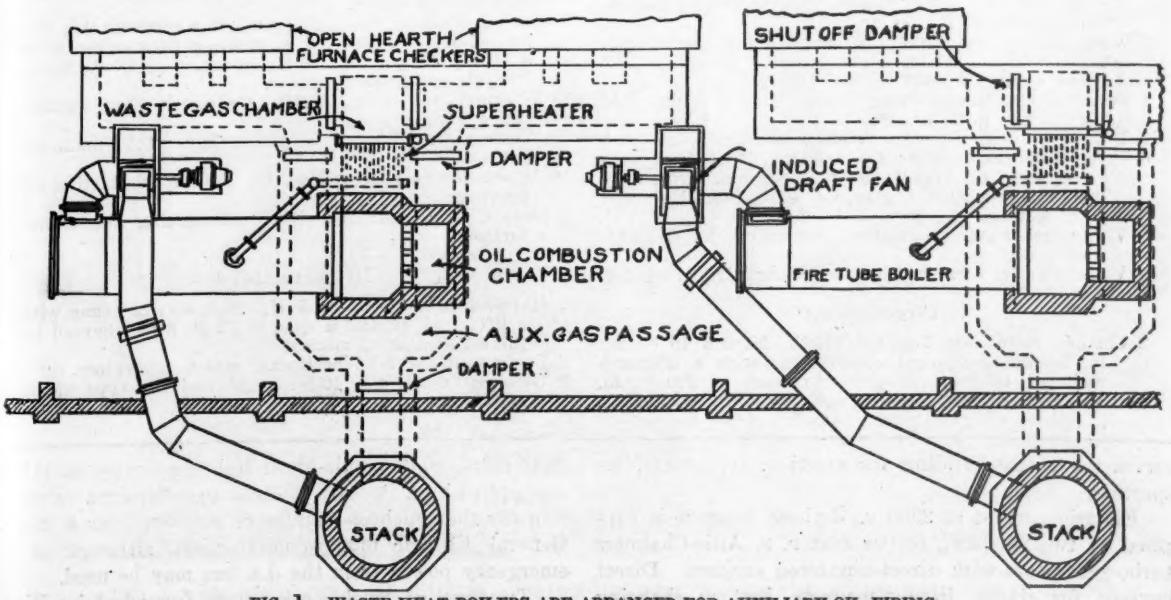


FIG. 1. WASTE HEAT BOILERS ARE ARRANGED FOR AUXILIARY OIL FIRING

generator when necessary. With the exception of the 300-kw. Westinghouse motor-generator set and the 2480-cu. ft. Ingersoll-Rand compressor, all equipment is new, giving complete freedom in arrangement and selection to meet specific requirements. A 20-t. Harnischfeger Corp. crane with a 40-ft. lift and 72 ft. 8 in. span serves the entire building for erection, repair and inspection.

Electric current at 2300 v., 3-phase, 60-cycle is supplied by two 2500-kw., 80-per cent P. F. Allis-Chalmers turbo-generators with direct-connected exciters. Direct current for cranes, lifting magnets, battery charging and variable speed motors is supplied by a Westinghouse 300-kw. synchronous motor-generator set and an Allis-Chalmers 750-kw. rotary converter served by 3-300-kv.a. transformers. Many of the larger motors are 2300 v., the smaller ones of 440 v., receive current through 100-kv.a. Westinghouse transformers connected delta-delta, while single-phase lighting service at 115 v. is supplied by a Packard 25-kv.a. transformers. Excitation for the synchronous motors is taken from a 75-kw. General Electric motor-generator set, although in an emergency power from the d.c. bus may be used.

Twenty-nine black slate panels furnished by West-

Principal Equipment at Bettendorf Co. Plant

Location, Bettendorff, Iowa.
Service, electric, pneumatic and hydraulic.

Turbo-Generators

2 Allis-Chalmers Co. turbo-generators, 3600-r.p.m., 2500-kw., 80% P. F., 2300-v. 3-ph. 60-cycle, using 140-lb. 50-deg. superheat steam and 28 in. vacuum.

Condensers and Auxiliary Equipment

2 Allis-Chalmers Co. 2 pass, surface condensers, 54 in. by 14 ft. shells set parallel with, and below, turbines each having 4228 sq. ft. of cooling surface made up of 1539 ¾-in. tubes.
2 Allis-Chalmers Co. 14 in. Type S circulators discharging 5600 g.p.m. each against a total head of 43 ft. Direct connected to 440, 3 ph. 60-cycle, 865 r.p.m., 75-hp. Allis-Chalmers Co. induction motors with remote control.
2 Allis-Chalmers Co. 2 by 4-in. Type CS centrifugal hotwell pumps, designed to discharge 140 g.p.m. against a total head of 80 ft. Direct connected to 1725 r.p.m., 440-v. 3-ph., 60-cycle, 75-hp. induction motors.
2 Allis-Chalmers Co., Croll-Reynolds 2-stg. evactor air pumps with jet intercoolers. Capacity 19 cu. ft. per min. each.
1 Dayton-Dowd Co. 4-in. Type CS centrifugal pumps to return condensate to boiler room. Capacity 450 g.p.m. against 40-ft. head. Driven by a direct-connected, 1750-r.p.m., 440-v., 3-ph., 60-cycle, 7.5-hp. General Electric Co. induction motor.
1 Chain Belt Co. vertical traveling intake screen, ⅜-in. mesh, capacity 13,500 g.p.m. minimum. Driven by a General Electric Co. 5-hp., 1150-r.p.m., 440-v., 3-ph., 60-cycle motor.

Waste Heat Boiler Room

6 Freyn Engineering Co. 257-hp. boilers, single pass, high velocity fire-tube type, designed for 160-lb. pressure. Heating surface 3085 sq. ft. made up of 256 2½-in. tubes 20 ft. long. Shell dimensions 78 in. by 20 ft.
6 Superheater Co. bare tube external superheaters designed to give 100 deg. superheat.
1 Warren Webster & Co. double, open feedwater heater. Capacity 60,000 lb. per hr.
2 Westco-Chippewa Pump Co. single stage centrifugal, turbine-driven, boiler feed pumps. Capacity 200 g.p.m. against a total head of 180 lb.
1 Permutit Co. zeolite water treater with a capacity of 310,000 gal. in 24 hr.
1 Dorr Co. 30-ft. diameter settling basin.
6 Green Fuel Economizer Co. induced draft fans with a capacity of 12,500 cu. ft. per min. driven by Westinghouse Elec. & Mfg. Co. 40-hp. variable speed a. c. motors.
6 Victor feedwater regulators furnished by Wright-Austin Co.
1 Venturi meter furnished by the Builders Iron Foundry.

Compressors

2 Chicago Pneumatic Tool Co. 110-lb., 26 and 15 by 18-in. tandem compound compressors with a displacement of 4424 cu. ft. per min. each at 200 r.p.m. Driven by two 750-hp., unity P. F., 50-deg. C., 2300-v., 3-ph., 60-cycle Ideal Elec. & Mfg. Co. synchronous motors mounted directly on crank shaft.
1 Ingersoll-Rand Co. 110-lb. 27 and 16½ by 21-in., two-stage compressor with a displacement of 2480 cu. ft. per min. at 180 r.p.m. Driven by Westinghouse Elec. & Mfg. Co. 400-hp., unity P. F., 40-deg. C., 2300-v., 3-ph., 60-cycle synchronous motor, motor mounted on shaft.
2 750-sq. ft. aftercoolers.
1 400-sq. ft. aftercooler.
3 Ingersoll-Rand Co. 66 in. by 18 ft., 110-lb. air receivers with a total volume of 1280 cu. ft.

Hydraulic Pumps

2 Blake Pump & Condenser Co. 3500-lb., 3 by 15-in. duplex, double acting pumps with a displacement of 99.0 g.p.m. at 53.64 r.p.m. Geared with a ratio of 151 to 18 to two General Electric Co. 275-hp., unity P. F., 50-deg. C., 2300-v., 3-ph., 60-cycle synchronous motors.
2 Blake P. & C. Co. 1000-lb., 4 9-16 by 15-in., duplex, double acting pumps with a displacement of 228 g.p.m. at 53.64 r.p.m. Geared to two General Electric Co. 450-r.p.m., 175-hp., unity P. F., 50 deg. C., 2300-v., 3-ph., 60-cycle motors. Gear ratio 151 to 18.

Electrical Equipment

3 Westinghouse Elec. & Mfg. 100-kv.a. Type OISC transformers connected delta-delta. Primary volts 2300, secondary 230-460.
1 Packard Elec. Co. 25-kv.a., single phase, 2300 to 115-230-v. lighting transformers.
3 Allis-Chalmers Co. Type OISC transformers rated 300 kv.a. at 55 deg. C. Primary voltage 2300 v. used with
1 Allis-Chalmers Co., 750-kw., 40-deg. C., 900-r.p.m. rotary converter flat compounded, d. c. voltage 240, a. c. (6 ring) 177 v.
1 Westinghouse Elec. & Mfg. Co. 900-r.p.m., 300-kw., 40-deg. C., motor generator set, flat compounded, generator voltage 240 d. c., driven by a 450-hp., 80 per cent P. F., 40-deg. C., 2300-v., 3-ph., 60-cycle synchronous motor.
1 General Electric Co. 1200-r.p.m., flat compounded, 75-kw. 40-deg. C., 250-v. d. c. motor generator set with a 110-hp. 85 per cent P. F., 50-deg. C., 2300-v., 3-ph., 60-cycle synchronous motor.
29 Westinghouse Elec. & Mfg. Co. black slate switchboard panels.
19 Westinghouse Elec. & Mfg. Co. Type B 13 main oil breakers.
10 Westinghouse Elec. & Mfg. Co. Type F 22 starting oil breakers.
2 Ideal Elec. & Mfg. Co. air cooled starting auto-transformers.

Miscellaneous

1 Harnischfeger Corp. "P & H," 20-t. service crane with a lift of 40 ft. and a span of 72 ft. 8 in. Served by three 240-v. d. c. motors.
2 Swartwout Co. 8-in. horizontal steam separators.
2 Griscom-Russell Co. 10-in. angle receiver type steam separators.

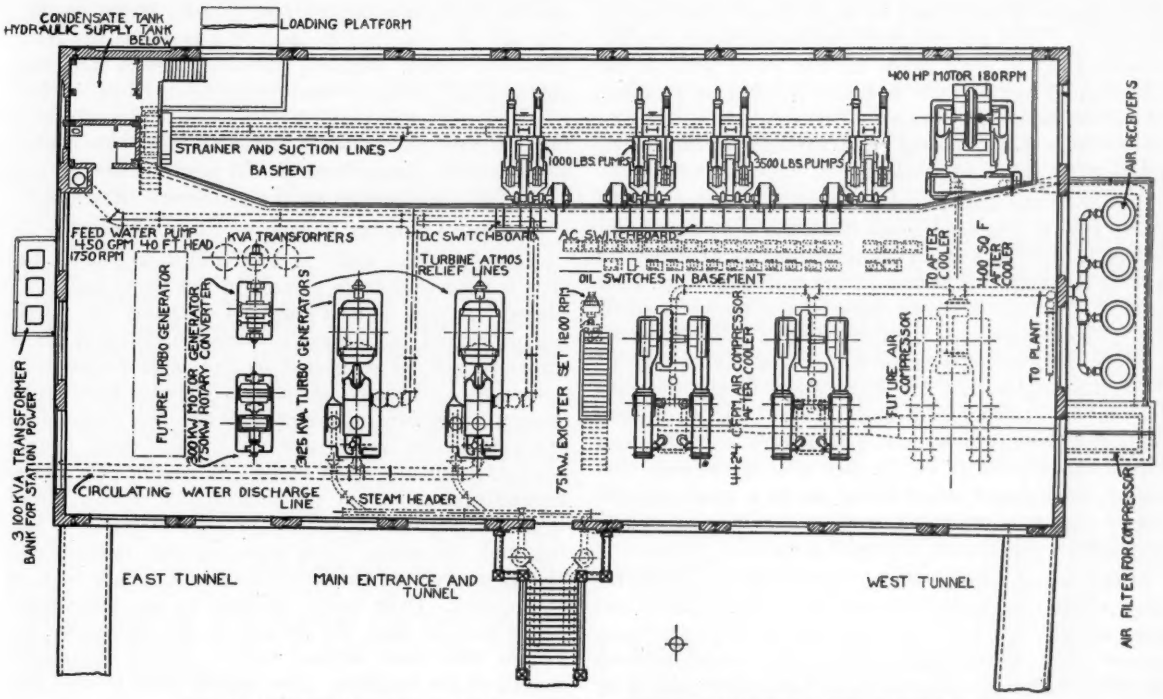


FIG. 3. GENERAL FLOOR PLAN OF BUILDING SHOWING PROVISION FOR FUTURE UNITS

inghouse are used in the switchboard, 7 panels in the d.c. section, the remaining 22 for a.c. service allowing two spares, one synchronous motor panel for the compressor and one generator panel for proposed generator. Figure 2 shows the general arrangement of both switchboards. Power to operate the solenoid for the oil switches comes from the motor exciter bus for closing and from a 24-v. storage battery for tripping.

Surface condensers, also supplied by Allis-Chalmers Co., are set parallel with and directly below the turbines. They are of the two-pass type with a surface of 4228 sq. ft. made up of 1539—¾-in. tubes. Cooling water, after passing through a Chain Belt Co. traveling screen with ⅜-in. mesh, is pumped through the condensers by two Allis-Chalmers 14-in. Type S centrifugal pumps driven by induction motors. Each pump delivers 5600

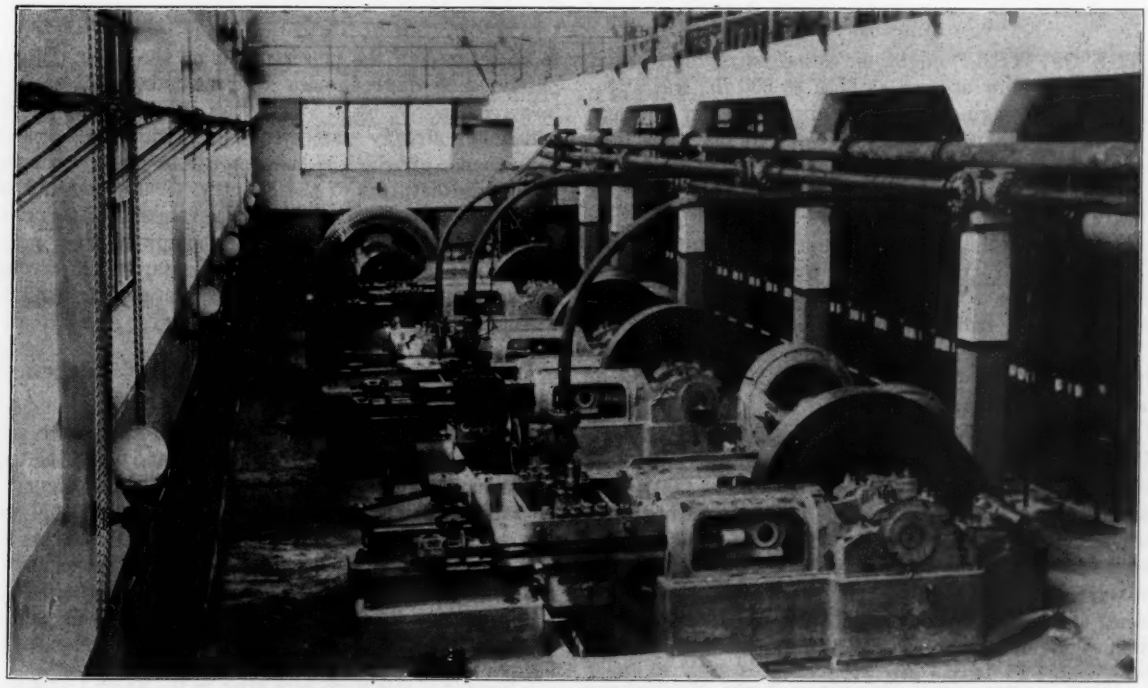


FIG. 4. THE BASEMENT FLOOR AS IT APPEARED SHORTLY BEFORE THE PUMPS WERE PUT IN SERVICE

g.p.m. against a total head of 43 ft. when operating at 865 r.p.m. They are remotely controlled, located some distance away in a pit below the low water level of the Mississippi River in order to insure continuous priming. Two 24-in. lines carry water to the condensers, the discharge from both flowing back through a 30-in. line sealed below the river level.

Motor-driven hotwell pumps with a capacity of 140 g.p.m. remove the condensate from the condensers and deliver it through a small jet condenser to a condensate tank in the southeast corner of the building. This tank built of concrete is shown back of the switchboard in Fig. 2, from here it is delivered to the boiler room by a single Dayton-Dowd motor-driven centrifugal unit of 450 g.p.m. capacity. Air is removed from the condensers by two-stage Allis-Chalmers Co. Croll-Reynolds evactors equipped with jet intercoolers. One unit with a capacity of 19 cu. ft. per min. serves each condenser, the exhaust steam being led to a small jet condenser over the condensate tank where it is condensed by the main condensate and gland water.

Compressed air at 100 lb. pressure is supplied to the shops. The two large Chicago Pneumatic tandem duplex machines, driven by Ideal Elec. & Mfg. Co. unity power factor, synchronous motors, have a deplacement of 4224 cu. ft. per min. each with capacity control by quarter steps. Air is filtered through 66 model C-5 Protectomotors into a 42-in. intake and each machine is equipped with a 750-sq. ft. aftercooler. The smaller compressor located on the basement floor is a 2480-cu. ft. Ingersoll-Rand machine, driven by a Westinghouse unity power factor synchronous motor. The aftercooler on this machine has a surface of 400 sq. ft. while volume control is also in quarter steps. Nearly 10,000 cu. ft. of free air per min. can be delivered to the shops for air hammers, drills, reamers, riveting presses and open-hearth steel furnaces through the three 66 in. by 18-ft. receivers placed in parallel at the west end of the building. Compressor cooling water is now furnished by steam-driven pumps from the old power house but eventually will be supplied by the condenser circulators.

Pump Capacity Varied by Suction Valves

High pressure water at 1000 and 3500 pounds pressure is used to operate presses in the shops and is furnished by four Blake Pump & Condenser Co. plunger pumps geared to General Electric synchronous motors. Capacity will be controlled by the accumulator travel, operating electrically, through a Holveck synchronized suction valve control system. When the accumulators reach their low levels, electric circuits close, energize solenoids and allow the suction valves to seat. At the normal upper limit of the accumulator electric circuits open and prevent the suction valves from seating. Loading and unloading takes place in one revolution although to prevent shocks loading occurs only on a suction stroke. Over travel switches on the accumulators are placed to stop the motors in an emergency. All pumps take their suction from a tunnel running the length of the building. The supply tank located below the condensate tank is piped up to receive the waste water as it is discharged from the presses so that it is virtually a closed circuit.

Although the plant has been in complete operation but a short time, results have been very satisfactory while indications are that figures predicted by engineering estimates will be exceeded.

High Pressure Turbines for Industrial Plants

Discussion of Advantages of High Pressure Turbines in General, Their Applications to Industrial Work and Analysis of a Typical Plant. By Francis Hodgkinson*

USE OF WHAT might be called extra high steam pressures, or at least as high as 600 lb., was advocated by some engineers occupied in the design of steam turbines more than ten years ago, and at that time they showed that some 7 to 10 per cent saving in fuel could be realized by this means. Among the reasons for not quickly adopting these higher pressures was that of increased boiler costs. Perhaps a more important one was the lack of the required courage by the individual who spent the money to try such a costly experiment, or risk the serious loss should such a plant not prove reliable. I believe that since then, manufacturers of steam turbines have been prepared to design turbines for any of the pressures thus far proposed.

It is true that the thermal functions of steam at very high pressures are not known with accuracy, and there are serious discrepancies between the various tables that have been published. None of the tables, however, differ markedly in the energy to be secured from the ideal engine in the steam expanding from a higher limit of pressure to a lower limit. At all events, the discrepancies are not such as to affect seriously the designer's calculations on the one hand, or the ultimate economies to be secured in the power plant, on the other. Fortunately, such discrepancies as exist today will soon be largely removed by the activities of the A. S. M. E., which has already partly completed valuable research, the expense of which is being borne in part by the turbine manufacturers of the country. The General Electric Co. is to be credited with some research of this character* and has compiled some comprehensive curves from the preliminary A. S. M. E. data, which, through the courtesy of its representatives, were made available at the December meeting of the society.

High Pressure Turbines Give Greater Economy Despite Lower Turbine Efficiency

It is to be expected that turbines to operate with extra high pressures will be less efficient (using the term "efficiency" in the strict sense) than those designed to operate with moderate pressures, because of the relatively small volume and high density of steam at the high pressure portion, rendering highly efficient turbine elements more difficult of attainment and the greater precipitation of moisture throughout the cycle adding friction to the low pressure elements, still further lower-

*Chief Engineer, South Philadelphia Works, Westinghouse Electric & Mfg. Co. Abstract of paper presented before Engineers' Club of Philadelphia, Feb. 16, 1926.

*Details of this work were given in the March 1, 1926 issue of Power Plant Engineering, "Steam Tables Developed from Harvard Experiments," page 316.

ing the efficiency. This latter may be reduced or nearly eliminated if reheating with its complexities is resorted to, or if a successful means is employed of draining the moisture from the turbine as latent heat is given up during expansion. In a measure, this last may be accomplished where stages of the turbine are bled for some industrial process, or where the regenerative principle is made use of in a plant heating its own feed water by stage bleeding.

The general thermal advantages of high pressures can be seen in Table I, showing the gains over 200 lb. absolute pressure, 200 deg. superheat, first with constant total heat in the steam supplied to the throttle, second, with constant superheat, and third, with constant total temperature. The performances are based on the performance of an ideal engine in all cases.

It is believed that engineers occupied in the designing of turbines foresee no particular difficulties in design even for the highest pressures thus far contemplated. It is fair to say, however, that not much is known concerning the erosive effect of this high density steam, and engineers will be wise, for the present at least, in designing these elements multi-stage and employing relatively low steam velocities. It is reported, however, that turbines in Europe are being constructed for 1800 lb., 925 deg. F. total temperature.

Increased Pressure Gives Greater Gain Than Increased Superheat

Fortunately, far greater gains in heat consumption per unit of energy are to be secured by increasing the pressure, at least in cases of large turbines. This is exhibited by the curves of Fig. 1 as applied to an ideal engine.

TABLE I. EFFECT OF HIGH STEAM PRESSURES (THEORETICAL) WITH 29-IN. VACUUM AND 79 DEG. FEED WATER

AT THROTTLE					% Gain Compared with 200# abs.press., 200°F.Superheat	
Press. Lbs. Abs.	Total Heat. B.T.U.	Super-heat. °Fahr.	Total Temp. °Fahr.	End Point ADIABATIC EXPANSION	Quality of Exhaust %	Per Unit of Steam Supplied	Per Unit of Heat Supplied
TOTAL HEAT CONSTANT							
200	1317.5	200	592	418.5	.815	0	0
350	Do.	169	601	450.5	.784	7.7	7.7
600	Do.	143	630	481.5	.755	15.1	15.1
1200	Do.	117	684	519.5	.719	24.1	24.1
SUPERHEAT CONSTANT							
200	1317.5	200	592	418.5	.815	0	0
350	1334.	Do.	632	469.	.793	9.4	8.1
600	1350	Do.	667	497.	.771	18.7	15.8
1200	1370	Do.	767	547.	.743	30.7	25.6
TOTAL TEMPERATURE CONSTANT							
200	1405	368	750	464.5	.855	11.1	3.9
350	1397	318	Do.	493.	.821	17.8	10.9
600	1386	268	Do.	516.	.785	23.3	19.4
1200	1360	183	Do.	542.	.738	29.4	25.4

These curves, being based on the performance of the ideal engine, must not be taken at their face value. There is, perhaps, some small effect of supercooling. The curves also assume equal efficiency of 100 per cent for all elements of the turbine. There may also be inaccuracies in the higher pressures because of uncertainties in the steam tables within these ranges.

In the designs of small capacity turbines and where the high pressure volumes are small, it is difficult to design the high pressure elements of so small an area that the turbine can avail itself of the pressure and be efficient. This is especially true if a high rotative speed commensurate with the steam volumes is not available. Today, however, such cases of difficulty in securing efficient design of the high pressure element need not be general, for any desired rotative speed may be employed for the high pressure element by means of gearing.

Usually, in cases of large power units, separate high pressure turbine elements will be employed, expanding from the extra high pressure desired to a convenient, relatively high exhaust pressure, perhaps one selected that is the best pressure at which to apply reheating, after which it is employed in other turbine units wherein it is expanded to the condenser pressure. The Westinghouse Co., a few years ago, completed designs of turbines to operate between pressure limits of 1200 and 300 lb., in which the high pressure turbines would exhaust into the main steam pipe to a group of normal turbines in which a flow of 125,000 lb. per hr. had been selected.

Because of the high density and small volume of steam throughout the high pressure element, high rotative speeds—not necessarily high blade speeds—may generally be employed, direct-connected machines for large, and geared ones for the smaller capacities, thus reducing the physical dimensions of the turbine proper, in turn reducing the probabilities of distortions of the turbine parts due to temperature itself and the differentials of temperature.

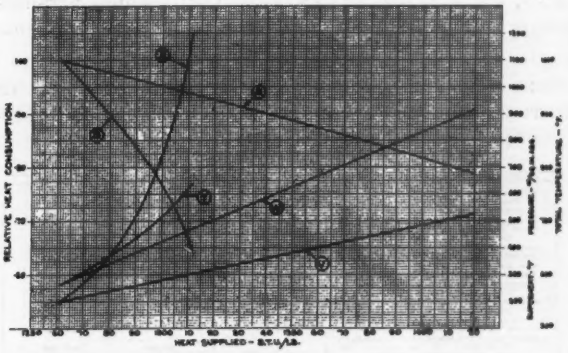


FIG. 1. RELATIVE GAINS IN HEAT CONSUMPTION PLOTTED AGAINST HEAT SUPPLIED, COMPARED WITH 200 LB. ABS. PRESSURE, 200 DEG. SUPERHEAT, 29-IN. VACUUM

A. Relative heat consumption due to increasing superheat, Curve V, and maintaining pressure constant, total temperature increasing as shown by W.

B. Relative heat consumption due to increasing pressure, Curve X and keeping superheat constant, total temperature increasing as shown by Y.

Conditions That Justify Industrial Turbine Installations

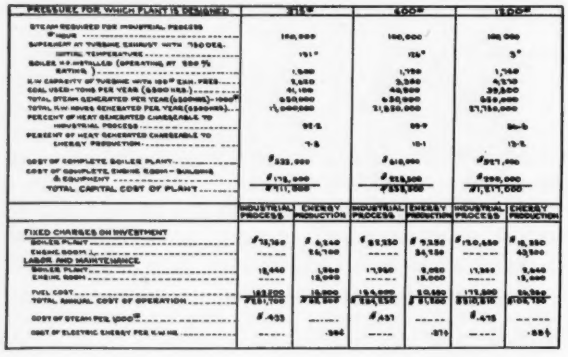
Thus far, my discussion has been more related to the application of high pressures to the large power units such as employed by our public utility companies, and I have rather indicated that high pressures do not lend themselves to the designs of turbines for the smaller units used in industrial plants except by means of gears. In fact, it may be fairly said that unless the industrial plant has need of steam heating in some form, it should be impossible for it to justify the installation of a power plant in view of the service which may be rendered by the public utility company in most districts. This will

become truer as interconnected power systems are extended and cheap energy is available in more places.

There are cases in the industries where steam is not required for any process, but a number of buildings must be heated during cold weather. In such instances, the installation of non-condensing turbines should be justified and mutually satisfactory arrangements possible with the public utility company. Similarly, in instances where exhaust steam at some pressure is used for process work, but the energy requirements are in excess of what could be obtained from this steam at any practicable high pressure, the highest practicable pressure may be selected and expanded in power units to the pressure desired by the heating process, the flow through the power unit being controlled by the requirements of the process and the difference between the energy thus given and that required being supplied by the utility company.

In instances where energy from the utility company is not available, or for some reason satisfactory arrangements cannot be made, bleeder type turbines, or combinations of high and low pressure elements, may be furnished. In fact, with the charges in the industrial power house properly apportioned, the public utility company will find it hard to compete. Unfortunately, however, there are so many varieties of pressures and ratios of process heating requirements to energy requirements, that the problem is difficult to meet with standard pieces of apparatus, requiring either high fixed charges because of special development, on the one hand, or lowered efficiency because of attempts to use standard apparatus, on the other.

TABLE II. ENERGY PRODUCED BY TURBINE WITH VARIOUS INITIAL PRESSURES, IN SUPPLYING 100,000 LB. OF INDUSTRIAL STEAM AT 100 LB. GAGE



An interesting paper on "The Value of Higher Steam Pressures in the Industrial Plant" was presented at the last December meeting of the A. S. M. E. by William F. Ryan, who speaks from the authority of a company that, possibly, has done more than any other in bringing about thermal savings in an industry involving a number of elaborate evaporating and heating processes.

Employment of extra high pressures means care in the design of the plant, to make it simple. Every unnecessary high steam pressure pipe line must be eliminated, or the cost of small valves may become enormous. Presumably, in all cases, distilled water only must be used as makeup for the boilers, so that complexities of evaporators are involved.

By way of example of an industrial plant, an assumed case is taken and shown in Table II, based on an industrial requirement of 100,000 lb. of steam at 100 lb. gage pressure. The industrial operation and energy production are taken as being continuous; in other words, 100 per cent load factor operation while operating, the year containing 6500 hr., and are based on the following assumptions:

POWER PLANT OPERATING AT 375 LB. PRESSURE

Cost of complete boiler plant.....$ 63 per kw.
Cost of complete engine room, building and equipment, excluding condensing equipment ..... 68 per kw.
Cost of complete condensing equipment, including condensing water system..... 19 per kw.

Total cost of entire power plant....$150 per kw.

The foregoing figures are for a plant operating with straight condensing turbines. For determining the cost of boiler equipment for a plant furnishing process steam, it is assumed one boiler hp. at 200 per cent rating will supply steam for 4.7 kw. for a condensing turbine. Then the cost of boiler plant per boiler horsepower installed will be $296.

Annual cost of maintenance, personnel and supplies, not including executive administration for boiler room.....$20,000
Annual cost of maintenance, personnel and supplies, not including executive administration for engine room..... 15,000
Coal—12,500 B.t.u. per pound.....per ton 5
Annual fixed charges—15 per cent of capital expenditure.

The following efficiencies are assumed:

Boiler, furnace and grate.....76 per cent
Turbine (engine efficiency).....70 per cent
Generator .....95 per cent

For increased pressures, assume the only change in power plant cost per kw. rating is in the boiler plant and small additional cost to turbine. The boiler plant cost is increased 15 per cent for 600 lb. and 80 per cent for 1200 lb. over the figure given for the 375 lb. plant; labor remaining the same. These boiler house ratios of cost have been taken from Mr. Ryan's paper. Capital expenditures will vary with every instance, and the assumptions made are necessarily to be regarded only as approximate.

Costs, pro-rated to the industrial process and energy production, respectively, are based on the respective heat energy going to each. The cost of the boiler house is apportioned in the same ratio. The engine room and its operation has all its costs and fixed charges charged against energy production, for, were it not for generating energy, no engine room would be required. Should the operation continue during the day time only, i. e., an eight-hour day the costs would increase to those shown in Table III. Because of banking fires, 70 per cent boiler efficiency is assumed. The labor cost is cut in half.

The case is carried somewhat farther with the supposition that the energy shown by Table II is not sufficient for the energy requirements and 4000 more kilo-

watts are required. These additional kilowatts, as has been previously indicated, may be purchased from a public utility company, or a bleeder type turbine may be installed instead of the back pressure turbine, in which a sufficient quantity of steam is admitted at the throttle, 100,000 lb. of which is bled at 100 lb. to this process heating, the same as before, the remainder expanding to a condenser in which 28½-in. vacuum is maintained.

Table IV shows, under the above assumptions, the cost of this additional energy; because much of the fixed losses in the machinery have already been charged, and due to the low fixed charges because of the small additional investment, a slightly more complex and larger turbine and a condenser to condense a fraction of the total steam, the cost of the extra energy is low.

In the table, it is assumed that this addition to the plant costs 0.8 of the original boiler plant horsepower cost and $51.00 per kilowatt for the engine room, excluding condensing equipment, which will be additional apparatus. No increase in labor and maintenance cost is taken for the engine room. The boiler house labor costs have been increased 40 per cent for this increase in boiler capacity.

Probably the only method of discovering the most economical pressure and superheat to be employed and the most economical combination of machinery in an industrial plant is to estimate as correctly as possible the probable load conditions and heating operations and then go through the somewhat laborious process of tabulating annual operating costs, including fixed charges, with all conceivable combinations with and without purchased energy.

TABLE III. FOR THE PLANT DESCRIBED IN TABLE II, COSTS WOULD INCREASE IF OPERATION IS ON 8-HR. DAY BASIS

PRESSURE FOR WHICH PLANT IS DESIGNED	315#		600#		1200#	
TOTAL STEAM GENERATED PER YEAR (1,700 HRS)-1000#	217,000		217,000		217,000	
TOTAL K.W. HOURS GENERATED PER YEAR ($170 HRS.)	3,680,000		7,280,000		9,560,000	
COAL USED-TONS PER YEAR ($170 HRS.)	14,900		14,540		13,440	
	INDUSTRIAL PROCESS	ENERGY PRODUCTION	INDUSTRIAL PROCESS	ENERGY PRODUCTION	INDUSTRIAL PROCESS	ENERGY PRODUCTION
FIXED CHARGES ON INVESTMENT						
BOILER PLANT	$13,760	6,240	$12,230	9,730	12,650	18,350
ENGINE ROOM	-----	26,700	-----	24,390	-----	43,240
LABOR & MAINTENANCE						
BOILER PLANT	9,210	780	8,990	1,120	8,650	1,320
ENGINE ROOM	-----	1,200	-----	1,200	-----	1,200
FUEL COST	$ 68,200	6,800	66,160	7,300	62,660	9,240
TOTAL ANNUAL COST OF OPERATION	$ 131,360	$47,020	$101,940	$56,310	$101,960	$82,310
COST OF STEAM PER 1000#	$.70	-----	$.75	-----	$.88	-----
COST OF ELECTRIC ENERGY PER K.W. HR.	-----	.5¢	-----	.5¢	-----	.6¢

Many Factors Influence Selection of Pressure

The pressure selected depends upon the factors given, viz., fixed charges, and the amount of energy desired from the process steam relative to that demanded by the heating steam. The best initial temperature is generally that which will give approximately dry saturated steam or a few degrees of superheat to the process, for the heat in the steam in the form of superheat can be but little more useful in the heater than in a steam engine or turbine. Besides, because of the superheated steam being a gas and of low specific heat above the point of saturation, hence having a low rate of heat transmission in the heater, more surface area is required. On the other hand, the heat in the steam, in the form of dry saturated steam above the heat in the liquid, can all be absorbed by the heating process, while the best engine can use but some 22 per cent of it.

In the industries there are cases where either water or some liquor merely has to be heated from some normal atmospheric temperature. In such instances, considerable savings are to be obtained by heating the liquor by bleeding the turbine in stages in the same manner that it is economical to heat feed water similarly. An instance of this kind occurred in an industry a short time ago where it was required to heat 870,000 lb. of water per hour from 115 deg. to 210 deg. F. In addition to this there were required 2500 kw. of additional energy. The purchaser contemplated bleeding steam direct from the boilers at 150 lb. gage pressure for this heating, and in addition, the installation of a 3500-kw. condensing turbine. On the recommendation of the manufacturer, the installation was arranged to be a turbine to the throttle of which 102,000 lb. of steam would be admitted, this turbine being bled in three stages at which water would be progressively heated to 148 deg. F., 179 deg. F. and 210 deg. F. When operating under these conditions, the turbine would produce 4610 kw., obviating the necessity of the 3500-kw. condensing turbine, and reducing the load on the condensing units already installed. The change in arrangement resulted in a reduction of capital expenditure of about $42,000, being difference in price between the straight condensing unit and the additional boilers that would have been required, and the cost of the complete bleeder unit. Furthermore, the annual fuel operating expense was reduced from $452,000 to $310.000. The saving obtained amounted to $148,300 per year.

TABLE IV. IF ENERGY SHOWN IN TABLE II HAD TO BE INCREASED BY 4000 KW., THE ADDITIONAL COSTS WOULD BE AS SHOWN HERE

PRESSURE FOR WHICH PLANT IS DESIGNED	315#	600#	1200#
ADDITIONAL CONDENSING CAPACITY TO BACK PRESSURE PLANT-K.W.	4000	4000	4000
ADDITIONAL BOILER H.P. REQUIRED	880	830	770
ADDITIONAL STEAM GENERATED-1000#	43,100	41,100	39,600
ADDITIONAL COAL USED-TONS PER YEAR ($300 HRS.)	19,150	18,180	17,540
ADDITIONAL K.W. HR. GENERATED PER YEAR ($500 HRS.)	26,000,000	26,000,000	26,000,000
COST OF ADDITION TO BOILER PLANT	$ 204,000	$ 223,000	$ 329,000
COST OF ADDITION TO ENGINE ROOM - BLDG. AND EQUIPMENT, EXCLUDING CONDENSING EQUIPMENT	204,000	204,000	204,000
COST OF COMPLETE CONDENSING EQUIPMENT	76,000	76,000	76,000
TOTAL CAPITAL COST OF ADDITION TO PLANT	$ 484,000	$ 503,000	$ 609,000
FIXED CHARGES ON INVESTMENT PER YEAR	$ 72,600	$ 75,500	$ 91,400
ADDITIONAL LABOR & MAINTENANCE COST PER YEAR	5,000	5,000	6,000
FUEL COST PER YEAR	98,900	95,900	87,700
TOTAL COST PER YEAR FOR ADDITIONAL POWER	$ 177,500	$ 175,400	$ 185,100
COST PER K.W. HR. FOR THE ADDITIONAL POWER	.68¢	.67¢	.71¢

As a general proposition, a turbine required to heat a liquor having a specific heat of 1, from 80 deg. F. to 210 deg. F. in a single-stage heater will develop 38.8 kw. per 1000 lb. of steam, assuming throttle steam at 150 lb. gage, 100 deg. F. superheat and a turbine efficiency of 70 per cent. If this same heating were done in three progressive stages to 125 deg. F., 172 deg. F and 210 deg. F., respectively, the same quantity of steam—1000 lb. would develop 51.3 kw., an increase of 32 per cent for no cost beyond the difference in the initial cost and fixed charges incidental to a slightly more complex turbine and the substitution of three smaller heaters.

Water jackets and intercoolers on air compressors should be cleaned and washed out as often as possible. The accumulation of mud, or sludge, decreases the efficiency of the water cooling and if neglected, may, in time, result in complete stoppage of the passages.

Automatic Combustion Control Necessary for Economy

By J. W. Pecler

DURING the last five years the writer has had the opportunity of visiting many power plants throughout the country and of making a careful study of the various phases of plant operation.

At some of the plants visited, nothing has been neglected in the way of proper operating equipment, while in others the most important feature of continuously efficient operation—automatic combustion control —has been omitted. In such plants one cannot help sympathizing with the chief engineer as he surely has a man's size job to operate such a plant whether it be large or small.

Dollar after dollar has been spent in such plants for nothing else but heating excess air that has been allowed to enter the furnace because the operating crew was trying to control too many things by hand and had gotten sick of the job. They followed the lines of least resistance, centering all of their activities on holding the steam pressure and preventing unburned fuel from entering the ash pit.

One cannot help but think of the difficulty one would have in steering an automobile down the road with the steering knuckle controlling only one front wheel and yet this would be fairly easy to the job of trying to steer a power plant down the road of efficiency with the type of labor of today without the assistance of some type of automatic combustion control.

8000-Hp. Plant Without Automatic Control

As an example of such condition, the writer has in mind a large eastern plant of eight 1000-hp. boilers and traveling grate stokers, seven of which operate 24 hr. per day, at 175 to 225 per cent rating, burning No. 3 buckwheat anthracite. This plant is equipped with the latest type of equipment throughout with the exception of an automatic combustion control system. Both the chief engineer and superintendent recognize the importance of automatic combustion control but are unable to interest the plant owners to the extent that such equipment would improve plant efficiency. Owners of the plant state that with a plant equipped such as this one the additional expense of automatic combustion control would be a waste of money as they have all that is needed to operate a plant. The type of labor available at this plant is of poor quality. Most of the men cannot understand English or don't want to when any additional work is mentioned. The stokers are equipped with steam driven forced draft fans, two to the installation; all settings are individual, each stoker being driven by a steam engine.

Being well acquainted at this plant, the writer has watched the struggle for the past 2 yr. The boiler room foreman was an energetic fellow and was determined to get the best efficiency possible from this plant, doing quite well for a while when the equipment was new to the operators who took enough interest in learning to do just what they were told. This, however, soon wore off after the operators got confidence enough that they could run the plant. They soon formed their own ideas of operation which, of course, involved the least amount of thinking or labor.

Carrying the load successfully meant almost continuous walking from one furnace to another, watching the length of the fires and keeping up the pressure as close to the popping point of the safety valves as possible. Since all fans and stoker engines were controlled only by hand, the result was almost continual blowing of the safety valves. The men were reprimanded for this and were instructed to slow down the forced draft fans in time to prevent the boiler popping and at the same time to retard the stoker engine speed in proportion to the speed of the fan. But the boiler damper was overlooked entirely. This put unnecessary vacuum in the setting, causing air infiltration and more excess air to be heated to the temperature of the exit gases.

It was one continual round of fight on the part of the chief engineer and boiler room foreman against these conditions. Men were discharged and new men put in their place who in a short time were up to the same tricks. The boiler room foreman worked himself sick and simply could not keep the plant operating at the efficiency it should have been. In due time both the chief engineer and foreman became disgusted and, losing heart, they too began to follow the easiest path.

If some good type of automatic control had been installed as soon as it was found necessary, this plant would have been operated at reasonably high efficiency from the start. This equipment would have done the running around for the fireman, he would have been quick to learn that it was his best friend and it would have received excellent care. This has been proved in many instances. In plants where all automatic control has been taken out of service for repairs and the operation relegated to manual control of the operators, they will quickly tell you their work has been doubled and will be glad when the control is put back in service.

It is practically impossible to control manually the supply of air and fuel to a furnace and still maintain the uniform conditions necessary for continuously high efficiency. Automatic combustion control is the plant owners' only hope of saving money otherwise unnecessarily spent for fuel.

The United States Civil Service Commission states that the $165,000,000 public buildings program now pending before Congress has passed the House and has been favorably reported to the Senate. The indications are that the bill will become a law. The bill provides for new construction work amounting to $100,000,000 outside the District of Columbia and $50,000,000 in the District of Columbia. It includes $15,000,000 to complete the unfinished portion of a building program ordered in 1913.

The Civil Service Commission has extended until June 30 the date for the close of the receipt of applications for positions of architects, associate architects, assistant architects, and associate and assistant architectural, mechanical, and structural engineers in connection with this work. The age limit for all these positions has been raised from 45 to 50 yr. Full information and application blanks may be obtained from the U. S. Civil Service Commission, Washington, D. C.

Design and Operation of Pulverizer Feeders

RAW COAL FEEDERS MAY BE GROUPED AS EITHER INTERMITTENT OR CONTINUOUS, THEIR DESIGN BEING GOVERNED BY PHYSICAL CHARACTERISTICS. BY S. C. MARTIN

FOR FEEDING and regulating the raw coal supplied to the mill, the pulverizer feeder is an important part of pulverized fuel equipment. In feeding material to a pulverizer it is desirable that the flow be fairly uniform at all times and in some types of machines that pulverize the coal and pass it directly into the furnace to be burned a few moments after it has entered the mill, a uniform feed is necessary for successful operation. With such machines a hold-up in the feeder for any considerable time may cut down the flow of pulverized coal and cause the flame to die out, while a rush of material in the feeder may clog the pulverizer and cause it to overheat or stop entirely.

ACTION OF FEEDERS CONTROLS COMBUSTION EFFICIENCY

Successful regulation of combustion in many installations depends to a great extent upon the action of the feeder. To design such a feeder that will feed successfully the different classes and grades of coal to a pulverizer requires a thorough knowledge of the physical characteristics of the material to be handled, as well as of its behavior with various methods of feeding.

Coal as fed to a pulverizing machine is generally far from uniform as regards size and shape of the pieces of material. Fine coal, as well as lumps of a variety of shapes and sizes, may be passing through the feeder at the same time. Even when the raw coal is crushed to a specified maximum size, the proportions of the fine and coarse particles produced will vary with the type of crusher employed as well as with the class of coal being treated.

Different surface characteristics peculiar to the various classes of coal will influence the behavior of the material in the feeder. Anthracite presents a harder and smoother surface and flows more readily than the bituminous coals, which are softer and pack more easily. Moisture has a great influence on the feeding properties of coals, especially when fine material in any considerable quantity is present. Important also are the angles of repose and of slide. With piled material the angle of repose varies with the different grades and classes of coal as well as with the amount of moisture present. For anthracite it is about 27 deg., for run of mine soft coal, 35 to 37 deg. and about 40 deg. for coke.

Another variable is the angle of slide, or the angle of incline of a surface down which the material will flow by gravity alone. Anthracite will flow down a steel plate chute inclined at about 20 deg. with the horizontal. Chutes for soft coal should be inclined at an angle of about 45 deg., and where the material is damp and contains any considerable quantity of fines, the slope should be greater. The angle of slide for coke is about 25 to 30 deg.

In order that there may not be too great variation in the size of the pieces of material entering the feeder, most manufacturers of pulverizers recommend that the coal be small enough in size to pass a 1¼ or 1½-in. ring. Large pieces of coal would require a large feeder and difficulty would be experienced in obtaining a uniform feed should it become necessary at any time to supply a small amount of material to the mill.

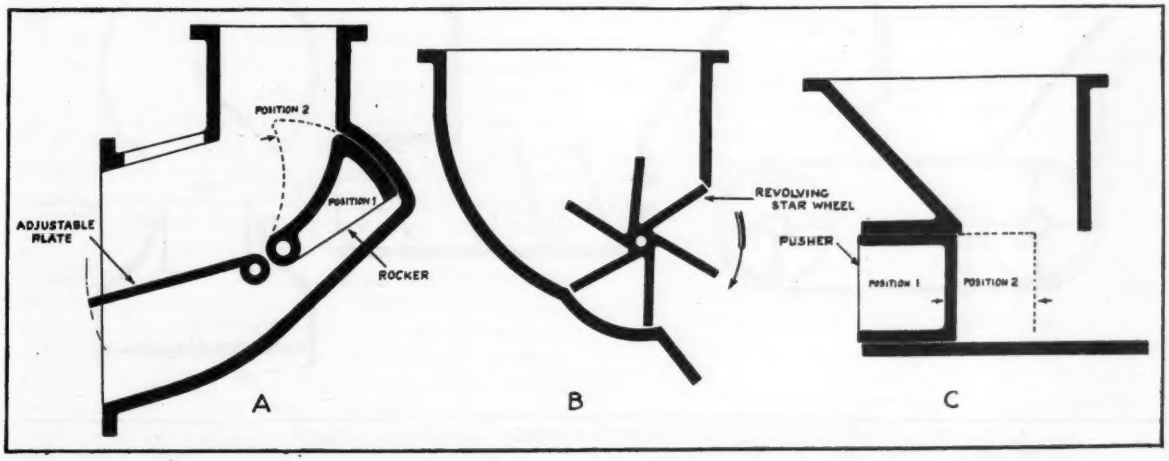


FIG. 1. THESE ILLUSTRATE INTERMITTENT TYPES OF FEEDERS: A, ROCKER; B, REVOLVING POCKET; C, PUSHER

In the design of any feeder we have three elements to consider: 1. Surface on which the material is supported; 2. Means for removing the material from the supporting surface, or the feed; 3. Means for regulating the quantity removed per unit of time.

In order to remove material from the support, motion must be imparted to the material, either indirectly by means of gravity, or directly from the supporting plate or the feed element. Gravity usually is utilized at some stage of the process for assisting the movement of the material. Motion imparted to the material may be either continuous or intermittent, and the methods employed may be those of scraping or pushing it from the supporting surface or plate; or the plate may be tilted or oscillated in order to permit the material to fall either intermittently or in a constant stream.

With regard to the kind of motion imparted to the

material, feeders may be grouped as either intermittent or continuous. In Fig. 1 are shown those of the former group with A as the rocker type, B revolving pocket and C as the pusher type. Figure 2 illustrates feeders of the continuous group, D being a belt feeder, E of the screw type and F of the revolving plate type.

Revolving pocket feeders, sometimes referred to as star wheel feeders, consist of a series of pockets or containers arranged radially around a central horizontal hub which is free to revolve on its axis. The pockets are filled automatically from a hopper in which a part of the wheel revolves and empty themselves as they are inverted after leaving the hopper and while completing the revolution. Such feeders are generally operated by means of a pawl and ratchet arrangement and are regulated by changing the speed of revolution of the pockets. If any great variation in the feed is required it may be necessary to change the capacity of the pockets by means of fillers.

In the pusher or plunger type of feeder a plunger or scraper pushes the material forward as it flows upon a stationary plate or other support. A reciprocating motion is given to the plunger by means of a crank or cam, and regulation is effected by changing the speed or the stroke of the plunger. Some lost motion may occur in this type of feeder on account of a portion of the material that is moved forward dropping back as the plunger recedes. This is especially noticeable if the material contains much moisture.

In the rocker feeder the pushing element is hinged and there is no scraping action as with some types of plungers.

In the group of feeders classed as continuous, while the motion imparted to the material may be continuous, unless such material is fairly dry and uniform in size the flow may be irregular. Revolving plate feeders of this class depend upon the friction between the material being fed and the plate for their successful operation. In designing such a feeder this factor should be considered and the sides of the housing so constructed that they retard as little as possible the movement of the material with the plate. A stationary scraper is fastened above the revolving plate in a radial direction in order to guide the material over the edge as the plate revolves. Regulation of the quantity fed is accomplished by changing the speed of the revolving plate. The quantity of material allowed to flow out upon its surface also may be controlled by raising or lowering a sleeve located above the plate.

Feeders employing a moving belt as a means of carrying the coal forward may have either a continuous or intermittent motion given to them. The latter allows of more simple means for regulating the motion of the belt. Regulation of the amount of coal fed is accomplished by varying the travel of the belt surface and also by controlling the amount of material allowed to flow out upon it from the hopper.

In the screw type of feeder the pitch of the screw is important. A pitch that is too steep will tend to cause the material to revolve with the screw instead of being forced forward. Regulation of the feed can be accomplished only by changing the speed of the screw.

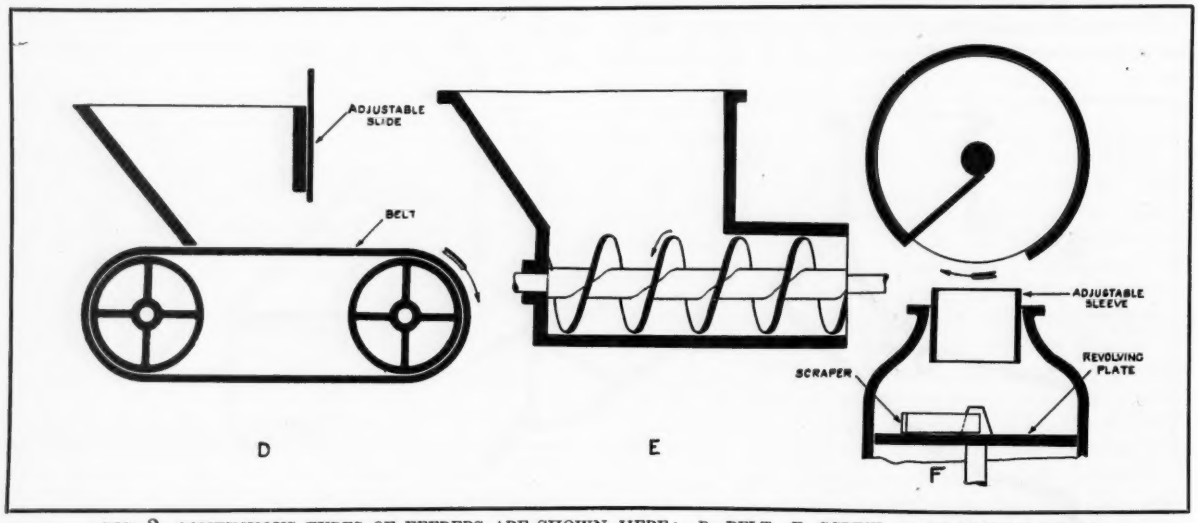


FIG. 2. CONTINUOUS TYPES OF FEEDERS ARE SHOWN HERE: D, BELT; E, SCREW; F, REVOLVING PLATE

In choosing a feeder for supplying raw coal to a pulverizer the fact should be considered that some types of feeders are better adapted for operation with one class of material than with another.

Little trouble is experienced in the operation of feeders where the material is dry and of fairly uniform size. Changing from one class of coal to another, or to coal containing a different amount of moisture, or supplying coal in which large pieces are mixed with considerable fine material, will generally necessitate an adjustment of the feeder to meet the changed conditions.

Principles of Coal Pulverizing Machinery

OUR ATTENTION has been directed to an error in the article under the above title appearing in the May 1 issue. This occurs on page 523, column 1, 3rd line from the top. The formula should read $3\times\sqrt[3]{a}-1$, not $3\times\sqrt[3]{a-1}$ as it appears.

DON'T EXPECT oil burners to burn properly if they are not kept clean.

Divided Counsel Costs Money

CONSIDERATION OF POWER SUPPLY FOR TWO SPECIFIC INDUSTRIAL PLANTS. BY MORGAN G. FARRELL

IT SEEMS to be about as difficult to get plant owners and their advisers to agree on the question of made or purchased power as on any other single problem of manufacturing. A notable example of the extravagant cost of such disagreement is that of an artificial stone company, whose inability to select one policy and stick to it has cost them to date, over $100,000.

Of course, it is comparatively easy to decide whether to make or buy power when the nature of the process is such that one or the other course is clearly indicated. In the case of textile mills or chemical plants, where there is a large consumption of live and exhaust steam for washing, drying, and heating, there can be no doubt that the home manufacture of power costs less than central station current. It is not as cheap as is generally supposed. It cannot by any means be obtained for nothing, as some plant engineers are in the habit of stating. But there is an appreciable differential in its favor.

As far as purchased power is concerned, a large number of manufacturing lines are, however, in the doubtful class. Sometimes it is actually doubtful whether the owners should buy power or not, and sometimes they only think it is doubtful. As an instance of the latter, the proprietors of a certain lumber and trim mill in Brooklyn, after mature deliberation, decided that they would not be bothered with a power plant, even though they had plenty of fuel waste, in the shape of sawdust, shavings, and blocks, and plenty of use for exhaust steam to supply their dry kilns. They would prefer, they said, to operate boilers only, burning the waste in the furnaces and generating steam at 30 lb. pressure not only for the dry kilns, but for the plant heating system generally. They acted accordingly, in the face of their engineer's report, which showed the relative costs of inside and outside power to be as in Table I.

Naturally, they were entitled to their opinion, and they were equally entitled to pay $6,340 a year to be relieved of the care of the power plant, if they saw fit.

It is not safe to state that the use for exhaust steam is always a conclusive argument in favor of operating non-condensing engines in the power plant. Other and counter-balancing considerations may be important. In fact, each case must be considered on its own merits, with a careful analysis of the arguments for and against the domestic plant.

TABLE I. COMPARATIVE COSTS OF MADE AND PURCHASED POWER

(Neglecting General Overhead)		
1. Cost of Making Steam.		
Investment in boilers, suction system and bins	$16,000	
Annual steam demand 250 b.hp. × 3000 hr. = 750,000 b.hp-hr.		
(a) Annual depreciation, interest, etc., @ 15 per cent.	2,400	
(b) Annual cost of delivering shavings to boilers	6,000	
(c) Annual cost of 1000-t. make-up coal	6,500	
(d) Annual cost of labor, supplies, upkeep	5,000	
Total cost of steam	$19,900	(1)
Or $.027 per b.hp-hr.		
2. Cost of Making Power.		
Investment in engine-room equipment	$24,000	
Average load 560 hp. connected load × 35 per cent load factor = 196 hp. which at 25 lb. water consumption = 142 b.hp.		
Annual power consumption = 588,000 hp-hr. = 441,000 kw-hr.		
Annual steam for power = 426,000 b.hp-hr.		
(a) Annual depreciation, interest, etc., @ 15 per cent.	3,600	
(b) Annual cost of power steam @ $.027	11,502	(2)
(c) Annual cost of labor, supplies, upkeep	7,600	
Total cost of power	$22,702	
Or $.0514 per kw-hr.		
3. Cost of Plant and Process Steam.		
(a) Total steam cost (1.)—Power steam cost (2)	$8,498	
(b) Plus engine exhaust, no charge	.....	
Total cost plant steam	$8,498	
4. Cost of Purchased Power as Billed.		
(a) 441,000 kw-hr. @ $.04	$17,640	
5. Comparative Overall Costs.		
I. (a) Cost of purchased power	$17,640	
(b) Cost of steam at full rate	19,900	
Total	$37,540	
II. (a) Cost of generated power	$22,702	
(b) Cost of plant and process steam.	8,498	
	$31,200	
Difference in favor of II	$ 6,340	

POWER PROBLEMS IN A STONE PLANT

The artificial stone plant, which will be used to illustrate the point in this article, is located along the tracks of an electrified section of one of the suburban railroads. It is not in a factory district, but stands almost alone in a tract given over entirely to scattered dwelling houses. The product of the company is not the ordinary cast cement block with which most of us are familiar, but is a high-class artificial stone, so cast and finished as to be suitable for the architectural embellishment of public buildings, banks and the like. This means that the mechanical plant includes conveyors for elevating sand, stone, and gravel from the hopper pits under the railroad siding to the storage bin, bucket conveyors for distributing the raw material, the mixing battery and the mixers themselves, which require continuously a considerable volume of electric power. Then there are the rotary screens and sand shakers for grading the raw ma-

terial according to the class or finish required for the stone. The larger pieces, such as column sections, are cast in pits in the floor which are entirely surrounded by steampipe coils, so that the drying can be kept under full control. As all the pieces cast at the plant are heavy, the shop is equipped with several high-duty travelling-cranes and a large number of electrically-operated jib-cranes.

After the stones are cast, they are often given an additional finish: bush-hammered, peened, vermiculated or ribbed finishes which are applied by power-driven tools, usually operated by compressed air. Beside all this is the usual complement of motor or air-driven drills, chip-hammers and saws, as well as a completely fitted carpenter shop for making up wood moulds.

It will be seen that the power demand of a plant of this kind is high and fairly continuous. In the plant under discussion, the electrical demand is 750 kw., at a practically constant load.

Pipe coils both in the casting pits and throughout the building for general heating, total almost 100,000 sq. ft., of which one-third is for heating the building in the winter.

Original Plant Equipment

As originally equipped, the engine room contained two 350-kw. direct-current generators, direct-connected to uniflow engines of the most economical type. They were run non-condensing, the exhaust steam being discharged into the heating system. A careful cost record had shown that the rate to produce current had averaged 3.67 cents per kw-hr. over a period of several years. The steam battery included three 300-hp. water-tube boilers of the best type.

Even under summer conditions the three boilers had about all they could do to furnish sufficient steam to operate the engines at full capacity, and to supply the pit coils with the necessary steam heating. In the winter time, the boilers were operated at 10 per cent above rating, but were unable to cope with the total power and steam load.

Engineers who were called in to examine the operating conditions at the plant and to make recommendations to relieve the situation found that the boilers were in good condition, the mechanical equipment well maintained, and that all machinery and tools were operated with a satisfactory choice and arrangement of individual and group-driven motors. Evaporation tests showed that the boilers were developing 110 per cent of rating, that the number of pounds of water per pound of coal as fired, was 6.5, and that the combined efficiency of boiler and furnace was 54 per cent.

Steam consumption of the engine was in the neighborhood of 17 lb. per hp-hr. The table of steam distribution can be summarized about as shown in Table II.

It is thus apparent that the balance between steam supply and demand was very delicately adjusted, so that it could easily be upset by disturbing factors such as periodic overloads on the process machinery, especially cold weather, or any unusual conditions.

As a matter of fact, the method of operation of the boiler plant was about like this: work started at the plant at 8 o'clock. From seven on, the firemen had been stoking the boilers with drafts wide open, to raise the steam pressure to the blowoff point. At 8 o'clock, the engines were turned over and the day's work started. For 2 hr. the boiler room force would continue to fight a losing battle against descending steam gages. On particularly bad days, the pressure would go down far enough to cause the engines to slow down. When that occurred, it was customary to shut down the entire mechanical plant for one-half hour until the firemen were able to prod the boilers back to normal pressure. Meanwhile, the workmen in the shop would turn to other tasks such as preparing molds, which required no power. When the pressure was again normal or a little above, the plant went ahead with its regular work for another 2 hr.

TABLE II. STEAM REQUIREMENTS

(a) For pit-coils 65,000 sq. ft on high-pressure steam	650 b.hp.
(b) For shop heating 35,000 sq. ft. on exhaust steam the equivalent of	350 b.hp.
(c) For engines and auxiliaries	417 b.hp.
Total	1067 b.hp.

It is a fact that when bad days were expected, the production department actually laid out its work to allow for the half-hour shutdown after each 2-hr. run.

After unsuccessfully trying to work out plans for distributing the day's work so as to reduce the power demand, the engineers gave it up and recommended the obvious, namely, to install another 300-hp. boiler. After considerable debate, the owners decided that it would be poor economy to spend $12,000 on a new boiler and the necessary piping, when there was a third rail with plenty of direct-current power within 200 ft. of the plant. They therefore made arrangements with the railroad company to tap the third rail for an auxiliary supply of current. The logic of that move is not apparent, inasmuch as it was a steam shortage and not a power shortage which was at the bottom of their trouble, as they soon found out.

Power Secured From Railway

They then tried another expedient, namely, the purchase of all power from the railroad, with a consequent shutdown of their own engine room. Their theory was that they would then have sufficient steam supply, inasmuch as the entire system of coils could be placed on high pressure. Previously, part of the coils had been arranged for high-pressure supply and part for the low-pressure exhaust steam.

This expedient proved fairly satisfactory as far as the heating system was concerned. But in the meantime, an investment of $45,000 in engines and generators was lying idle. Moreover, the supply of railroad current developed an unexpected eccentricity. As a heavy train came up the line, the plant motors would begin to slow down, and the lights to grow dim. As the train sped on past, the motors would again pick up speed, and the lights would again brighten. Although no specific damage was done by this fluctuation of power, it caused a certain amount of annoyance, especially during the traffic rush hours, when trains were passing by every few minutes.

Lighting Company Secured Power Contract

About this time, a representative of the local lighting company called at the plant to initiate a campaign for taking over its entire power load. The owners, who felt that they had made a mistake in purchasing power from the railroad, were looking about eagerly for a way out. They seemed fated to go from bad to worse, for not only was the public service power supply alternating current, while all the plant equipment was direct current, but the nearest line of sufficient capacity to supply the plant was nearly 2 mi. distant.

To shorten the story, they finally signed a contract with the lighting company, under the terms of which the company agreed to carry a high-tension line to a point on the nearest highway, which was nearly one-half mile distant from the plant. At that point the owners were to build, at their expense, a transformer house. They were also to purchase and install the transformers and the secondary lines to the plant. Incidentally, they purchased a rotary and installed it in the engine room.

Whether they had ever had a clear conception of the power rates was uncertain. It is not improbable that they had made wrong calculations and had decided that they were disposing of their power costs in the most advantageous manner. At the end of the year, however, they again sent for one of the consulting engineers who had originally reported to them.

When the engineer called upon the treasurer, he found him sitting behind a heap of bills and contracts. Without preliminaries, the treasurer plunged into the subject. The combined power and light bills were nearly $300 a day, about $90,000 a year. Did that seem reasonable? The engineer assured him it did not; that he knew of mills with a connected load of twice 700 kw., whose power bills were less than $90,000 a year. An analysis of all charges showed that, leaving out of consideration the first cost of the installation, the plant had been paying an average of 4.4 cts. per kw-hr. This sounded like a rather stiff price, considering the size and nature of the load, which was fairly constant and about the same as the maximum demand.

Further analysis of the bills for installing the alternating current to and including the converter, showed that the total outlay had been as follows:

TABLE III. COST OF A.C. INSTALLATION

1. Converter in place, connected up	$25,000
2. Transformer house	12,000
3. Transformers	8,000
4. Secondary wiring	25,000
Total	$70,000

To this, the engineer said, must be added the depreciated cost of the abandoned generating plant, which was not less than $30,000, so that the total cost of getting the alternating-current supply to function was, in round numbers, about $100,000. Allowing for interest, insurance and depreciation, or 15 per cent on all of that investment, it was evident that another $15,000 must be added to the annual bill for power, which brought the average cost per kw-hr. to 5.13 cents.

"But," said the treasurer, "I do not yet see the fallacy of our reasoning. The lighting company must be able to make current more cheaply than we can. Why should the $90,000 power bill be more than $15,000 more than our own costs, as certified by the auditors three years ago?"

The engineer pointed out that the public service company was in the business of supplying lighting current to an entire suburban area; that their power load was comparatively small, being limited to a few minor factories and an ice plant or two; that the total kilowattage of their isolated plants was less than 10,000; and that their distribution and feeder lines were long and costly. When all these factors were taken into consideration, he said, it must be apparent that the lighting company's costs for power delivered at the plant transformer house must be out of all proportion to their cost of generation.

The treasurer admitted that it might be so.

"Whether it is so or not," he continued, "the fact is that we cannot escape from the kilowatt-hour rate under the present system. What would you advise us to do?"

"Scrap your converter, transformers and the secondary line, buy yourselves off from your contract with the lighting company, go back to your original plan of operation and put in another boiler as we advised you to do in the first place."

"In other words," said the treasurer, "we scrap $70,000 worth of equipment, pay the lighting company what they demand to cancel the contract, spend $12,000 more for a boiler and its connections. How much do you think all that will amount to?"

"Before answering that," replied the engineer, "let me see what I can do in the way of negotiations with the lighting company. I believe that I can sell the converter and transformer and the secondary wiring. You will probably be able to salvage something out of every item but the transformer building. Perhaps you can find some use even for that."

The cancellation of the power contract was finally compromised for one-half the cost of the primary line which ran along a main highway and so could readily be utilized for the transmission of low-voltage power for house equipment, as electric ranges. The total salvage by the sale of secondary equipment was $20,000, so that the net cost of the experiment came to about $60,000 in the end.

Here was a case in which an honest differenec of opinion as to the relative merits of continuing to manufacture power or of buying it led to a heavy financial loss, not to mention several years of worry and annoyance. It could have been prevented in the first instance, if the owners had been content to accept the advice of competent and impartial authorities, whose familiarity with the economics of operation of public service companies enabled them to state authoritatively that the lighting company in question could not possibly compete under the physical conditions with the owner's own plant. They could also have advised their clients what would happen when they connected up with the railroad supply.

The problem of analyzing the external and internal conditions which affect the decision to make or purchase power for plants which lie in the borderland, between those for whom purchased power is clearly indicated and those for which it is evidently unsuitable, is a delicate one. An offhand settlement by inexpert persons is likely to prove expensive.

Power Development in the Great Lakes Area

AN OUTLINE OF THE PRESENT STATUS OF POWER DEVELOPMENT AS PRESENTED IN THE REPORT OF THE POWER SURVEY COMMITTEE OF THE N. E. L. A.

IN ESTIMATING or predicting future conditions, whether it be with respect to population, power requirements, weather or any other thing one may be interested in, it is essential first, to make an accurate study of present conditions. In making the power survey of the Great Lakes Division recently published, the Power Survey Committee recognized this fact and their report as a consequence contains a highly accurate statement of power conditions in the Great Lakes area at the present time.

The power survey territory, as stated in a previous article dealing with this report, is composed of the states of Wisconsin, Illinois, Indiana, Michigan, the greater portion of Minnesota and Iowa, the eastern portion of Missouri, nearly all of the west half of Kentucky, and the northwestern corner of Ohio. This territory, according to the United States Census of 1920, has a population of 15,716,200.

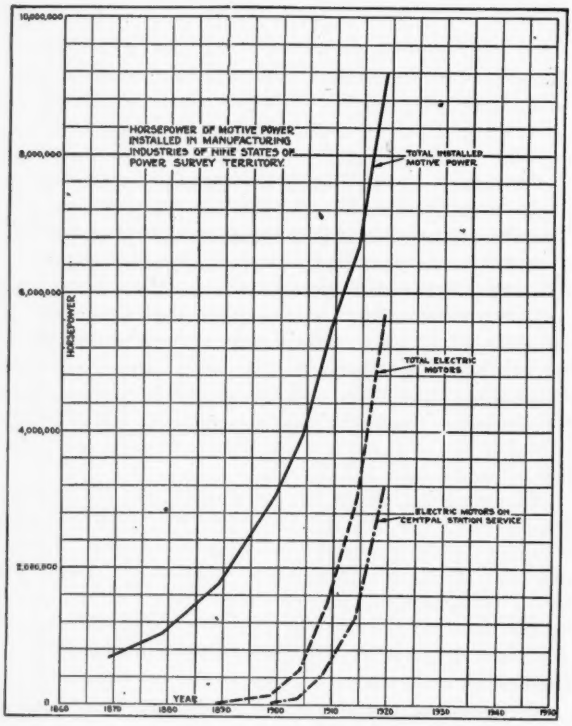

HORSEPOWER OF MOTIVE POWER INSTALLED IN MANUFACTURING INDUSTRIES OF NINE STATES OF POWER SURVEY TERRITORY.
TOTAL INSTALLED MOTIVE POWER
TOTAL ELECTRIC MOTORS
ELECTRIC MOTORS ON CENTRAL STATION SERVICE
HORSEPOWER
YEAR

FIG. 1. MOTIVE POWER IN MANUFACTURING INDUSTRIES OF NINE STATES IN THE TERRITORY

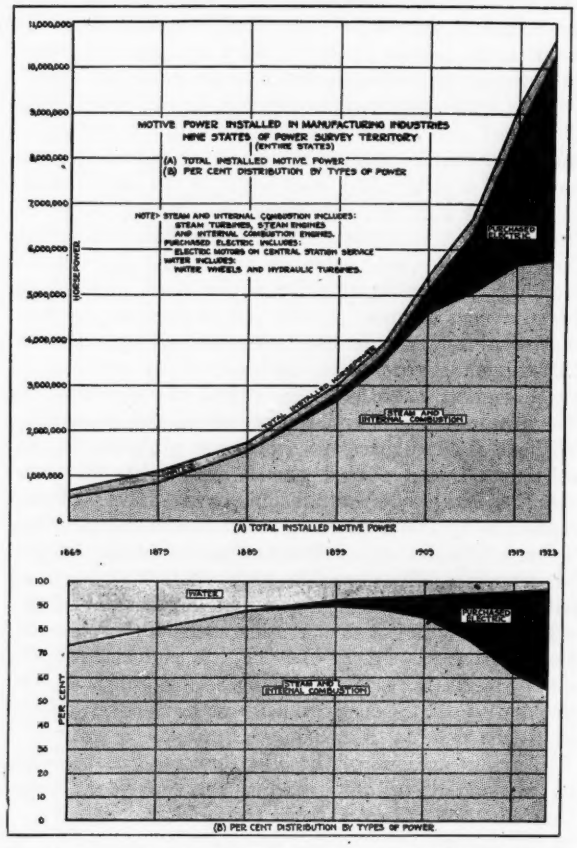

MOTIVE POWER INSTALLED IN MANUFACTURING INDUSTRIES
NINE STATES OF POWER SURVEY TERRITORY
(ENTIRE STATES)
(A) TOTAL INSTALLED MOTIVE POWER
(B) PER CENT DISTRIBUTION BY TYPES OF POWER
NOTE: STEAM AND INTERNAL COMBUSTION INCLUDES:
STEAM TURBINES, STEAM ENGINES
AND INTERNAL COMBUSTION ENGINES.
PURCHASED ELECTRIC INCLUDES:
ELECTRIC MOTORS ON CENTRAL STATION SERVICE
WATER INCLUDES:
WATER WHEELS AND HYDRAULIC TURBINES.
HORSEPOWER
STEAM AND INTERNAL COMBUSTION
(A) TOTAL INSTALLED MOTIVE POWER
WATER
PURCHASED ELECTRIC
STEAM AND INTERNAL COMBUSTION
PER CENT
(B) PER CENT DISTRIBUTION BY TYPES OF POWER

FIG. 2. TYPES OF MOTIVE POWER IN MANUFACTURING INDUSTRIES OF NINE STATES

Naturally, the principal load centers of this area are the cities of largest population, which have grown to their present size because of certain natural advantages. They were located before the generation of electricity was known and commerce early made those placed on waterways the important ones. Later, these waterways became natural sites for generating stations and the cheap power resulting has furthered the growth of these cities as industrial centers.

As an abundance of water for condensing purposes is an absolute requirement for an economical steam station, the Great Lakes and the larger rivers are the natural locations where such stations are found. In the central part of the territory the land is comparatively flat and does not offer much opportunity for hydro-electric development. The northern part is traversed by many rapidly flowing streams so that water powers abound in Minnesota, Wisconsin and Michigan. Iowa has a number of small water powers as well as the largest water power development in the territory at Keokuk on the Mississippi River. The Sanitary District of Chicago has a water power development with an effective capacity of about 20,000 kw. and the state of Illinois is planning to develop several water powers of somewhat similar capacity as a part of the navigation development of the Illinois River.

Along the southern portion of the territory are a number of water power sites, the development of which has recently been undertaken. The Dix River project in Kentucky with a 270-ft. high dam has just been placed in operation. Development of the Ohio Falls at Louisville is now under way, amounting to over 100,000 hp. A list of the large steam and water-power stations is given in Table I. The total generating capacity is summarized in Table II.

Power Resources

According to Table II, about 15 per cent of the installed capacity in the Territory is water power. There are many possible water-power sites remaining, but their total capacity is not great enough to alter the general situation. This part of the country must always place the most dependence on steam power from coal, although there are a few internal-combustion engines burning oil where special conditions justify their use.

As the production of fuels is not usually obtainable for smaller areas than entire states, it is difficult to secure figures for the exact area of the Power Survey Territory. Consequently, the data in this section all refer to entire states.

TABLE I. LARGE GENERATING STATIONS IN POWER SURVEY TERRITORY, 1925

Steam Stations		Water-Power Stations	
Location	Capacity Kilowatts	Location	Capacity Kilowatts
ILLINOIS			
Blue Island	48,500	Lockport (Sanitary District)	28,000
Chicago (5 Stations)	836,000		
East Peoria	40,000		
East St. Louis	120,000		
Grand Tower	50,000		
Harrisburg	25,000		
Joliet	50,000		
Moline	46,000		
Peoria	28,000		
Rockford	33,000		
Venice	56,500		
Waukegan	60,000		
INDIANA			
Dresser	60,000	Norway	6,000
East Chicago	28,000	Oakdale	10,000
Fort Wayne	31,000		
Indianapolis (2 Stations)	88,000		
Mishawaka	80,000		
MICHIGAN			
Battle Creek	50,000	Alcona	8,000
Detroit (3 Stations)	453,000	Berrien Springs	7,200
Detroit (Municipal)	67,000	Brule	6,000
Marysville	50,000	Cooke	9,000
Zilwaukee	40,000	Croton	9,000
		Edenville	6,000
		Five Channels	6,000
		Foote	9,000
		Hodenpyl	16,500
		Ingalls	6,000
		Junction	16,500
		Rogers	6,750
		Sault Ste. Marie	46,000
		Twin Falls	6,000
WISCONSIN			
Milwaukee	61,000	Cauldron Falls	8,000
St. Francis	130,000	Cedar Falls	6,000
		Jim Falls	12,000
		St. Croix Falls	21,400
		Wissota	31,680
		Kilbourn	6,000
		Prairie du Sac	22,000
		High Falls	6,000
		Big Falls	10,000
MINNESOTA			
Minneapolis (2 Stations)	124,000	Coon Rapids	6,500
St. Paul (2 Stations)	80,000	Fond du Lac	12,000
		Minneapolis (2 Stations)	15,350
		Royalton	13,500
		Thomson	54,000
IOWA			
Cedar Rapids	36,000	Keokuk	120,000
Davenport	25,000		
Des Moines (2 Stations)	48,000		
MISSOURI			
St. Louis	110,000		
KENTUCKY			
Louisville (2 Stations)	119,000	High Dam	22,560
OHIO			
Toledo (2 Stations)	143,500		

Seven of the nine states in the Territory are producers of coal. The principal deposits are in Illinois, Indiana, Kentucky and Ohio. The nine states of the Territory produce over 33 per cent of the bituminous coal output of the country. The annual output of coal for the past several years is shown in Table III.

The same four states that produce the bulk of the coal are also large producers of petroleum and natural gas. There are three oil fields that lie in the Territory. The Illinois-Southwestern Indiana field near Lawrenceville, Illinois, and the Lima-Indiana field near Lima, Ohio, are wholly within the Territory. The Appalachian field lies partly in Ohio and Kentucky. There are also several large refineries in the Territory that receive oil through pipe lines from distant fields including the Mid-Continent. The nine states of the Territory produce about 3 per cent of the petroleum output of the country, and refine a great deal more than this. They also produce nearly 10 per cent of the natural gas, and, by means of large pipe lines, consume about twice as much as they produce.

TABLE II. GENERATING CAPACITY IN POWER SURVEY TERRITORY PUBLIC UTILITY PLANTS, 1924

State or Section	Steam Power Kilowatts	Steam Power Per Cent of Total	Water Power Kilowatts	Water Power Per Cent of Total	Total Power Kilowatts
Illinois	1,463,370	96.79	48,527	3.21	1,511,897
Indiana	501,898	96.58	17,763	3.42	519,661
Michigan	697,819	80.38	170,280	19.62	868,099
Wisconsin	303,100	64.82	164,537	35.18	467,637
Minnesota*	277,042	67.02	136,333	32.98	413,375
Iowa*	195,681	59.23	134,692	40.77	330,373
Missouri*	183,727	100.00	0	0	183,727
Kentucky*	143,290	99.85	222	0.15	143,512
Ohio*	169,181	97.92	3,600	2.08	172,781
Great Lakes Division	2,966,187	88.09	401,107	11.91	3,367,294
Power Survey Territory	3,935,108	85.34	675,954	14.66	4,611,062

*Figures for portion of state in Power Survey Territory only.

†From various sources, including data submitted by the companies and McGraw Central Station and Electric Railway Directories.

This part of the country is well supplied with coal resources, sufficient to supply all the power stations that are likely to be built here for hundreds of years to come. In addition, those stations located on or near the Great Lakes have available additional sources of coal supply from the Appalachian field by means of combined rail and water transportation.

TABLE III. COAL PRODUCTIONS BY YEARS, 1918-1924

State or Section	1918	1919	1920	1921	1922	1923	1924 Estimated
Illinois	89,291,000	60,863,000	88,725,000	69,603,000	58,468,000	79,310,000	67,880,000
Indiana	30,679,000	20,912,000	29,351,000	20,320,000	19,133,000	26,229,000	22,340,000
Michigan	1,465,000	997,000	1,490,000	1,142,000	929,000	1,172,000	820,000
Wisconsin	.....	.....	.....	.....	.....	.....	.....
Minnesota	.....	.....	.....	.....	.....	.....	.....
Iowa	8,192,000	5,625,000	7,814,000	4,531,000	4,335,000	5,711,000	5,100,000
Missouri	5,668,000	3,980,000	5,370,000	3,552,000	2,925,000	3,403,000	3,140,000
Kentucky	31,613,000	30,036,000	35,691,000	31,588,000	42,134,000	44,777,000	43,000,000
Ohio	45,813,000	35,877,000	45,878,000	31,943,000	20,954,000	40,546,000	29,200,000
4 States of Great Lakes Division Total	121,435,000	82,772,000	119,560,000	91,065,000	78,530,000	106,711,000	91,040,000
Per Cent of U. S.	20.96	17.77	21.03	21 89	18 60	18 92	18.84
9 States of Power Survey Territory Total	212,721,000	158,290,000	214,319,000	162,679,000	154,878,000	201,148,000	173,480,000
Per Cent of U. S.	36.71	33 98	37 69	39 11	36.68	35.65	35.90
United States Total Bituminous	579,386,000	465,860,000	568,667,000	413,922,000	422,268,000	564,157,000	483,380,000

Transmission Lines and Interconnections

Transmission systems covering large areas and supplying local distribution systems were developed in the Territory many years ago. Thirty-three thousand volts predominated for the principal systems until the present decade, one notable exception being the early use of higher voltage for long transmissions in the Lower Peninsula of Michigan. In recent years, while the lower voltage lines have increased at a rapid pace, there has been considerable development at higher voltages, 66,000 and 132,000 predominating, with a considerable amount of 110,000-v. lines in the northwestern section of the Territory.

These high lines are being developed largely as parts of the systems of individual companies and, extending

across their own territories, gradually come to meet similar lines of adjoining systems with which they interconnect and thus join the various systems into a unified network. This gives to the connecting companies individually the advantages of diversity and of reserve capacity in the interconnected systems. It is apparent that there will be a great increase in the number and mileage of these high-voltage lines, which are destined to become parts of one of the very important and comprehensive power-supply systems of the country. Every extension of high-voltage lines should be designed to fit in readily with such comprehensive development. To this end there must be universal adherence to the standards of voltage and frequency of the region.

Some of the high-voltage lines thus far built are intended solely for trunk service between power stations, or from power stations to particularly large and important distributing centers. Others are planned for some distribution or interchange along the way, thus being simply a larger and more powerful type of the customary transmission line of the past. Interconnection of adjoining companies and systems is generally practiced throughout the nine states, and a large number of the smaller companies purchase their whole requirement from the transmission-line companies.

The nine maps of "Electric Service and Transmission Lines" (not reproduced in this abstract) show that electric service has been widely developed throughout all the states. Each map is well covered with spots indicating electric service, and a large percentage of the spots are interconnected in some way with others. As determined by scaling the maps, the length of transmission lines in individual states is shown in Table IV. In round figures, there are already 2000 to 7000 mi. of transmission lines between towns in each of the nine states, and the average is over 5000 mi. The splendid network of power transmission in the Territory is being further developed with more and higher-voltage trunk lines which will carry to market, in the most economical manner, the energy from the highly efficient power stations of the present and the future.

TABLE IV. LENGTH OF TRANSMISSION LINES IN NINE STATES OF POWER SURVEY TERRITORY

State or Section	Miles of Line
Illinois	7,090
Indiana	5,367
Michigan	4,570
Wisconsin	5,816
Minnesota	5,910
Iowa	6,890
Missouri	3,822
Kentucky	2,094
Ohio	6,017
4 States of Great Lakes Division	22,843
9 States of Power Survey Territory	47,576

General

That great preparations for the future are amply justified is made clear by a consideration of the nature of the Territory. Its strategic position and commercial importance are well known. More exact statistics show that although it contains about 12 per cent of the land area of the country, it has already 22 per cent of the population. While the average population density of the United States is 35.5 persons per sq. mi., all the states or portions of states in the Territory exceed this average. The whole territory has an average population density nearly double that of the United States.

The Territory contains the greatest railroad center of the country—Chicago—and many others of importance, such as Toledo, Indianapolis, Louisville, St. Louis, Peoria, Des Moines, Milwaukee, Detroit, the Twin Cities of Minneapolis and St. Paul, and the Tri-Cities of Illinois and Iowa: namely, Moline, Rock Island and Davenport. Most of these are rail and water terminals on the country's growing system of inland waterways. Some other places are large shippers by water of raw materials, such as iron ore from Duluth and Ashland, or copper from Hancock.

Of the 12 economic centers located by the Bureau of Census for 1920, 7 are within the Territory; namely, Center of Population, Center of Number of Farms, Center of Gross Farm Income, Center of Improved Acreage in Farms, Center of Cereal Production, Center of Corn Production, and Center of Oats Production. Four others are in the states partly included in the Territory, but a few miles outside. These are the Center of Value of all Farm Property, in north central Missouri; Center of Wheat Production, in the southwest corner of Iowa; and the other two centers, Value of Manufactures and Number of Wage Earners in Manufactures, both in west central Ohio. The only statistical center of the Census which is at all remote is the center of Cotton Production, located in Mississippi. Computations have been made of the Center of Electricity Production at intervals about 5 yr. apart from 1902 to 1921. Since 1912 the Center of Electricity Production has been located in east central Illinois and in 1921 (the last point given) was 3 mi. from Urbana.

According to the U. S. Geological Survey estimates of water power in 1925, the nine states of the Territory contained 4.58 per cent of the potential water power of the country, but had 13.41 per cent of the developed water power.

The installed capacity of all public-utility plants in the United States in June, 1924, was computed by the Geological Survey as 17,800,000 kw. Studies made by the committee show that approximately 4,600,000 kw., or 25 per cent of this capacity, was in the territory.

Comparison of the tables relating to population and power production shows that in 1924 the nine states produced 15 per cent of the water power, 36 per cent of the fuel power, and 29 per cent of the total public-utility power of the United States. The per capita generation of the Great Lakes Division in 1924 was 602 kw-hr., and of the entire nine states was 505 kw-hr., while that of the United States was 527 kw-hr.

The Power Survey territory itself occupies 71 per cent of land area of these nine states, and has 72 per cent of their population. Compared to the United States, it has 12 per cent of the land area and 22 per cent of the population; includes 25 per cent of the installed capacity in public-utility plants; and generates about 13,500,000,000 kw-hr., or 23 per cent of the output from public-utility plants. The per capita production of electricity in the territory is thus about the same as the average of the whole United States, and the production per sq. mi. of area is about twice the average of the United States.

Importance of Heat Transfer in Oil Heaters

SINCE MOST FUEL OILS MUST BE HEATED FOR ECONOMICAL COMBUSTION, PROPER SIZE AND TYPE OF HEATER INVOLVES CONSIDERATION OF VELOCITY AND VISCOSITY OF OIL. BY T. J. ESS

FUEL OIL has come into such widespread use that its handling and utilization presents its problems to a great part of the present day engineers. Although the use of a certain fuel is usually dictated by local conditions in different localities, such as low cost or advantageous transportation rates, the advantages set forth by another fuel may cause it to be adopted, even at a higher first cost. Or perhaps some particular process requires a fuel more suitable, either chemically or physically, than the prevalent fuel of the locality. It is perhaps due to these general reasons that the use of oil is not confined alone to the oil regions, but is widely distributed over the entire country.

In descriptions of fuel oil installations the storage usually is first considered. Storage capacity depends on the consumption of the plant, the source of supply, space conditions of the plant, etc. Tanks should be kept outside of buildings if at all possible and may be either above ground or buried. If above ground, fire insurance companies usually insist on a dike surrounding the tank of sufficient capacity to hold the entire contents of the tank. Perhaps the safest method of storage is the underground tank but the most common seems to be the outdoor steel tank above ground. Some plants pump from a large storage tank into smaller service tanks and from these to burners.

Heavy oils must be heated so that they will flow easily. If the storage tank is small, a flat coil of pipe may be installed over the entire bottom of the tank, using about one square foot of heating surface per 1000 gal. of capacity in buried tanks, and 1.5 to 2 sq. ft. per 1000 gal. for outside tanks, depending on the climatic conditions. If the tank is large, so that the cost of heating the entire tank would be excessive, a heating coil around the suction pipe is usually sufficient. It is to be remembered that these heating elements are merely to bring the oil to a condition so that it may be pumped easily. All tanks should be well vented to allow any vapors to escape and in no case should the tank be higher than the pumps.

OIL TRANSFER SYSTEMS MUST BE FLEXIBLE

Under this head are included the pumps, heaters, strainers and auxiliary equipment. The requirements of pumps for supplying oil to burners are: 1. They must be able to start when the oil is cold; 2. They must be able to supply any quantity of oil from their maximum capacity down to small quantities; 3. They must supply the oil in a steady flow, without pulsations.

Although some rotary pumps are used, the foregoing conditions usually lead to the installation of a reciprocating pump, usually of the direct steam-driven double-acting duplex type. They should have bronze piston rings and bronze valves with ground seats, and should be installed in duplicate, piped so as to cut out either pump without interfering with operations of the system.

In large systems, the pumps should be equipped with regulators, usually of the spring-controlled diaphragm type, which varies the steam throttle valve, maintaining a constant oil pressure.

Some manufacturers are putting out complete oil systems, combining the various auxiliaries required. Figure 1 shows a system of this type, with the pumps mounted over the heaters, completely equipped with regulators, strainers, and temperature control.

Heavy oils require heat in addition to that introduced in the storage tanks, so as to obtain high combustion efficiency. The high viscosity of these oils prevents thorough atomization and proper ignition when cold, and requires excessive pressure for pumping. Therefore,

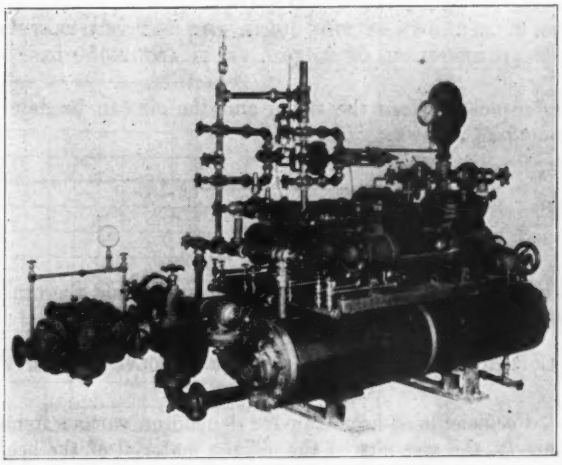


FIG. 1. THIS IS A DOUBLE DUPLEX, STEAM-DRIVEN, FUEL OIL PUMP TOGETHER WITH A HEATER AND STRAINER

sufficient heat should be supplied to overcome these difficulties. Steam usually is the medium employed for heating. Care should be taken, however, not to heat the oil above its vaporization point, as in this case the burners will sputter and heating conditions become difficult. Also, an excessive amount of steam is required. If the oil vaporizes, the pumps may become gas-bound. Any water contained in the oil may be made into steam at the higher temperatures, causing the tank to foam dangerously. Figure 2 shows proper temperatures for oils of various densities.

As in all such heat transmission problems, use is made of the formula:

$$S = \frac{C \times W \times (T_1 - T_0)}{d \times U}$$

where S = square feet of heating surface; C = specific heat of oil; W = pounds of oil used per hour; T_1 = final temperature of oil; T_0 = initial temperature of oil; U = coefficient of heat transfer in B.t.u. per sq. ft. per hr. per deg. F.; and d = the logarithmic mean temperature difference between the oil and the steam. The specific heat of oil may be taken as 0.48 for average temperatures. W, T_1 and T_0 depend on the installation, but in designing oil heaters a final temperature of 200 to 225 deg. F. should be allowed. The mean temperature

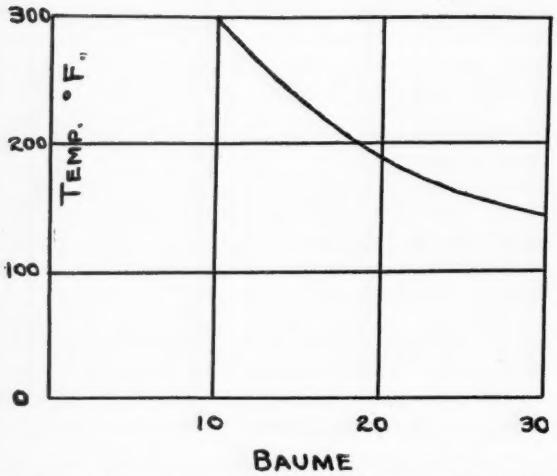


FIG. 2. AS SHOWN BY THIS CURVE, THE BEST TEMPERATURE FOR ATOMIZING OIL OF 25 DEG. BE. IS ABOUT 150 DEG. F.

difference between the steam and the oil can be determined as follows:

$$d = \frac{T_1 - T_0}{\log_e \frac{T_s - T_0}{T_s - T_1}}$$

where T_s = the temperature of the steam and the other values are as above.

Coefficients of Heat Transfer Involve Viscosity and Velocity

Coefficients of heat transfer depend on various items, namely, the viscosity of the oil, the material of the heating element and the velocity of the oil over the heating surface. We will first examine the effect of velocity.

Many sets of data have been published showing the relation between the velocity of oil and the coefficient of heat transfer, and the values given therein differ widely. This is due largely to the different types of heaters and the methods used in testing them. In some types of heaters, it is difficult to obtain an actual value for the velocity over the heating surface and this is responsible for much of the difference.

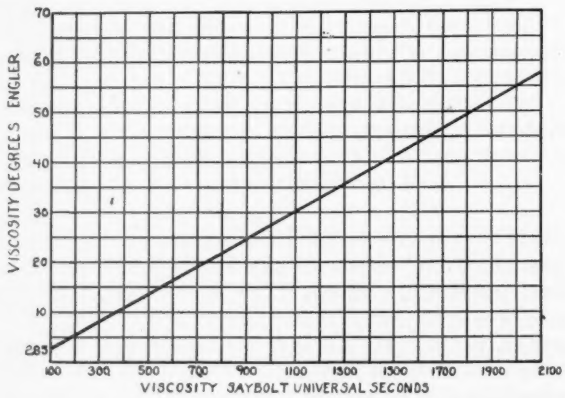


FIG. 4. IF YOU HAVE A SAYBOLT UNIVERSAL VISCOSIMETER YOU CAN CONVERT THE READINGS TO DEGREES ENGLER BY MEANS OF THIS CURVE

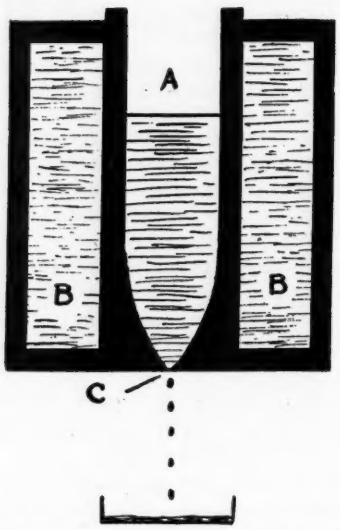


FIG. 3. THIS IS A CROSS SECTION THROUGH A VISCOSIMETER. OIL DROPS FALLING AT C ARE COUNTED FOR A GIVEN LENGTH OF TIME

Insulating qualities of oil are known by almost everyone. It is common knowledge that a mere film of oil in boilers cuts down heat flow from the hot gases to the water materially. The same thing is encountered in heating oil. Hence it is that heaters which break the oil into small sections and produce a turbulent flow, with a scrubbing action of the oil over the heating surface, give such excellent results. These higher velocities, however, produce a greater pressure drop, which calls for larger pumps, so that a balance must be struck between a large heater and smaller pumps, or a smaller heater with larger pumps.

If heating tanks are used which have a large volume in relation to the consumption of the system, the usual values of heat transfer do not hold. In such cases, convection in the oil takes the place of flow velocity. One case of this kind is an installation of four outdoor storage tanks supplying oil to furnaces at the rate of about 2500 gal. per hr. These tanks are provided with heating surface but in winter considerable difficulty was experienced holding the temperature.

Accordingly, a heater was installed close to the fur-

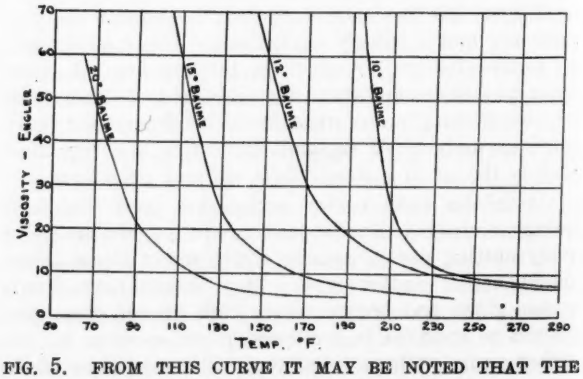


FIG. 5. FROM THIS CURVE IT MAY BE NOTED THAT THE VISCOSITY BECOMES LOWER AS THE TEMPERATURE INCREASES AND THAT THIS VARIES FOR OILS OF DIFFERENT DENSITIES

naces, consisting of a tank 4 ft. in diameter and 12 ft. long, set vertically. Oil was fed into the bottom of the tank and out the top. Two helical units of 1-in. pipe, one within the other, with all joints welded, furnished the heating surface, and steam was led in the top and out the bottom, establishing a counter flow to the oil. With this auxiliary heater operating, the temperature in the storage tanks could be lowered, thereby reducing heat losses. The auxiliary heater was lagged with a heat insulating material to reduce heat losses from this source. Steam flow to the heating elements was governed by a thermostatic control and a recording thermometer was also provided. This tank holds about 20 min. supply of oil which is larger than necessary but results have been excellent. Although the velocity of the oil flow is low, being only 12 ÷ (20 × 60), or 0.01 ft. per sec., a heat transfer rate of 35 B.t.u. per sq. ft. per hr. per deg. F. is indicated by the performance of the heater, showing that transfer of heat by convection must enter into the case. A good average value to use for heaters of this type is 25 B.t.u. per sq. ft. per hr. per deg. F.

is lowered, it becomes easier for the oil to transfer heat by means of convection.

Viscosity is simply the technical name for body or fluidity. As previously shown, it is the time required for a definite volume of oil at a definite temperature to flow through an orifice of definite size and shape with a definite head.

Viscosity is frequently given at one temperature only, yet two oils may have the same viscosity at one temperature and vary considerably at another. The variation of the body of the oil with the temperature is a characteristic of the crude from which the oil is made. Any oil thins out when heated, the viscosity becoming lower the higher the oil temperature.

There are several types of viscosimeters on the market. The Saybolt Universal and Saybolt Furol are in general use in the United States, the former for testing oils in general, the latter for testing road oils and other extremely viscous fluids. The Redwood viscosimeter is the standard in England and the Engler in Germany. The latter also is used in the United States to a large extent for fuel oils and asphaltic materials. Viscosity is given by the Engler instrument in degrees and by all others in seconds.

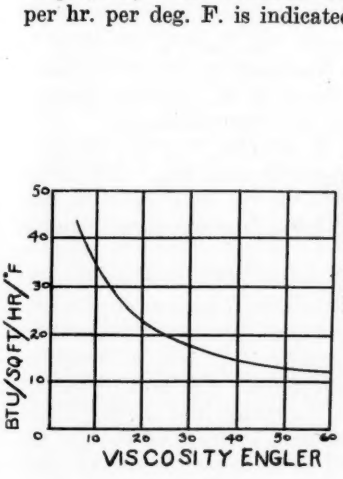


FIG. 6

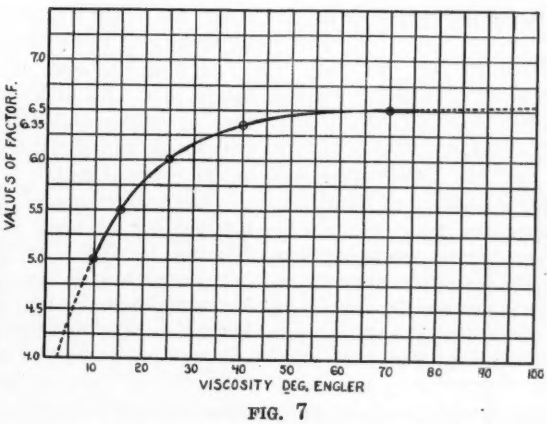


FIG. 7

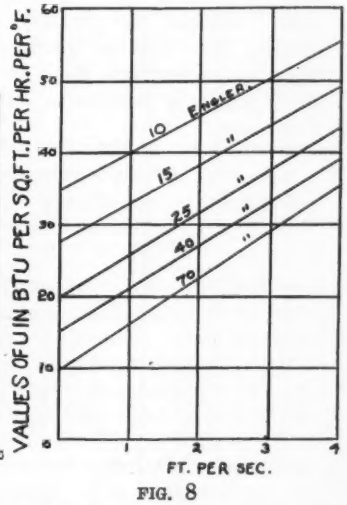


FIG. 8

FIG. 6. AS THE VISCOSITY INCREASES, THE OIL BECOMES LESS TURBULENT AND THE RATE OF HEAT TRANSFER DECREASES AS SHOWN BY THIS CURVE WHICH GIVES VALUES FOR ZERO VELOCITY. FIG. 7. FOR PROPER DETERMINATION OF HEAT TRANSFER THE VELOCITY MUST BE MULTIPLIED BY FACTOR F WHICH IS GOVERNED BY THE VISCOSITY. VALUES OF THE CURVE BELOW 10 AND ABOVE 70 DEG. ENGLER ARE SPECULATIVE. FIG. 8. THESE CURVES SHOW THE COMBINED EFFECT OF VELOCITY AND VISCOSITY ON THE CO-EFFICIENT OF HEAT TRANSFER IN OIL HEATING

Viscosity Affects Heat Transfer

Heat transfer is affected also by the viscosity which is determined by means of a viscosimeter. A diagrammatic view of one type of this apparatus is given in Fig. 3. Oil is put into the pipette A, whence it flows through the small orifice at C. The oil can be brought to any temperature desired by means of the water bath B, which is heated in various ways. The time required for a given amount of oil to run through the orifice is noted and the viscosity varies with this time. In flowing through the pipette, the moving mass of the oil acts as an infinite number of concentric tubes slipping over each other. The oil at the center has the maximum velocity, while the layer next to the tube is practically at rest. Therefore, the velocity of the oil through the tube is relative to the internal friction of the oil. As the viscosity is then a measure of internal friction, it will follow that as the viscosity (or internal friction)

In Fig. 4 is given a curve for converting Saybolt Universal viscosity in seconds to degrees Engler. In approximate figures, Saybolt Universal may be converted to degrees Engler by multiplying by 0.028, to Redwood by multiplying by 0.80, and to Saybolt Furol by multiplying by 0.105. Saybolt Furol may be converted to Engler by multiplying by 0.267 and Redwood to Engler by multiplying by 0.035.

In the curves in Fig. 5 the variation of the viscosity with temperature is shown for oils of different densities. Exceptions will be found to these curves, inasmuch as oils of the same density but from different localities often have different viscosities, but in general the viscosity varies with the density. The curves given here are averaged from tests, and are sufficiently accurate

for our purposes. It will be seen that the viscosity drops rapidly as the temperature begins to rise, but at the higher temperatures, the curves flatten out.

Perhaps as much accuracy as necessary may be obtained from the formula:

$$U = X + fV$$

where U = the coefficient of heat transfer in B.t.u. per sq. ft. per hr. per deg. F.; values of X as in Fig. 6; values of f as in Fig. 7; and V = the velocity of oil flow in feet per second.

With the density of the oil, the initial temperature of the oil entering the heater, and the desired final temperature of the oil known, an average viscosity can be determined. Then, from Fig. 6, which gives coefficients of heat transfer for various viscosities, an average coefficient can be obtained corresponding to this average viscosity. This curve is obtained by starting with a point attained in practice and superimposing the straight line relations between viscosity and velocity, upon which viscosity tests are based, and between velocity and heat transfer as given by the empirical equation above.

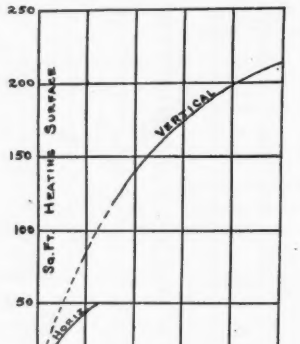


FIG. 9. THESE CURVES SHOW THE HEATING SURFACE REQUIRED FOR VARIOUS CAPACITIES OF HEATERS

On the basis of the formula previously given for the determination of the coefficient of heat transfer U, which combines the effect of both velocity and viscosity and using the values found in Figs. 6 and 7, curves shown in Fig. 8 were plotted. Values of the coefficient of heat transfer for 5 different degrees of viscosity between 10 and 70 Engler inclusive are shown. Intermediate values of U may be found by interpolation or more exactly, by calculation.

Figures from manufacturers seem to average 5 to 10 sq. ft. of heating surface per 100 gal. per hr., depending on their individual practice. This points to values of 25 to 50 B.t.u. per. sq. ft. per hr. per deg. F. as the coefficient. Figure 9 gives the practice of one manufacturer for various capacities in heaters of the return tube, or porcupine, type. This would indicate that heat transmission is better in the horizontal than in the vertical heaters.

Copper tubes show a better rate of transmission than steel or iron, being about 1.6 times as great, but there is a contention that the sulphur in the oil attacks the copper. It is for this reason that steel or iron is the usual material.

Points to be noted in the design or selection of heaters are: 1. Ease of cleaning—some oils will coat the heating surface with a layer of carbonaceous deposit which is a poor heat conductor; 2. Allowance for expansion—due to the uneven temperature in the heater, uneven expansion is set up; 3. Freedom of joints—there should be as few joints as possible within the heater.

G. E. Produces Two Methods for Obtaining Ductile Welds

TWO METHODS for producing ductile welds have been developed by research scientists of the General Electric Co., working in different laboratories hundreds of miles apart. Both of the methods, similar in some respects, mark a decided step in the utilization of the heat of electric arcs in the joining of metal parts or the building of metal structures. The one was developed in the Schenectady research laboratory by Dr. Irving Langmuir; the other was developed in the Thomson research laboratory at Lynn, Mass., by Peter Alexander.

In both processes, air is excluded from the metal by means of a bath of hydrogen or other gas. The formation of oxides and nitrides in the weld metal is thus prevented, and the fused metal is as strong and ductile as the original metal.

Announcements of these radically new methods of arc welding are made in the March issue of the General Electric Review. In brief, the method developed by Dr. Langmuir in Schenectady is to pass a stream of hydrogen between two electrodes. The heat of the arc breaks up the hydrogen molecules into atoms. These combine again a short distance in front of the arc into molecules of the gas, and in so doing liberate an enormous amount of heat, so that much higher temperatures can be obtained with this than with the usual welding methods. Since atomic hydrogen is a powerful reducing agent, it reduces any oxides which might otherwise form on the surface of the metal. Alloys containing chromium, aluminum, silicon or manganese can thus be welded without fluxes and without surface oxidation.

The process developed in the Lynn laboratory by Mr. Alexander is based on the utilization of the chemical and physical properties of hydrogen and other gases in their molecular state. This process aims primarily at the prevention of the formation of the nitrides and oxides in the arc-deposited metal, which limit the ductility of the usual arc welds.

In this process the arc is struck between the metallic wire or carbon used as one electrode and the plate or work to be welded used as another electrode. The crater of the arc is always on the work to be welded. The gaseous atmosphere is supplied in the form of a stream around the arc. Pure hydrogen, water gas, hydrogen-nitrogen mixtures, anhydrous ammonia, methanol vapor and some other suitable gases can be used, according to the nature of the work. The hydrogen-carbon monoxide mixtures were suggested by Professor Elihu Thomson; water gas and methanol are examples of such mixtures.

This process makes the arc welding process more efficient and suitable for the fields which at present are out of its reach. Low carbon steel, alloy steels, and most of the non-ferrous metals and alloys can be welded with success by this process in suitable gaseous mixtures.

Duties of a Diesel Engineer

SUITABLE OPERATING AND MAINTENANCE SCHEDULES ARE IMPORTANT. BY M. L. BLACK*

WHILE THE ENGINEER in charge of a Diesel plant has duties that are somewhat different from those that the steam engineer is called upon to perform, essentially the differences are not great—both must keep the plant machinery in working condition. A steam engineer need have no fear of not being able to handle an oil engine plant. Of course, he must first learn the general principles of the engine, but the details of the machine will speedily be mastered by daily attendance.

In starting the oil engine we found that it was necessary to have but one man in attendance. The engineer bars the engine over for one complete revolution, before starting, to detect the presence of water or any lost part in the cylinder. He then bars the engine to the position where starting air will enter the cylinder having the air starter valve gear. A few hand strokes of the fuel pump fills the oil lines, the bypasses are then closed and two more strokes given the pump before air is admitted to the fuel valve. The air starter bottle is then opened and the engine turns over. As soon as a cylinder starts firing, the air starter gear is thrown out and the fuel valve of this cylinder brought into gear. The engine at once comes up to speed and is ready to have its load. The engineer lets it run for, say, one minute without load, observing that the cooling water is flowing, the force feed oilers in operation, and so on.

He then steps to the switchboard, builds up the voltage on the exciter, closes the generator field switch, builds up the generator voltage and parallels the unit. To do this we have a synchroscope and a governor control at the switchboard so it is an easy matter to get the frequency correct.

HOURLY LOG INSURES ATTENTION OF OPERATOR

To insure proper attention to the engine we found a log necessary. On this log the engineer at each hour sets down the exhaust temperature of each cylinder, the cooling water inlet and exit temperature, the temperature of the main bearings, the fuel tank level, the room temperature, the switchboard instrument readings and oil added to the circulating system. Main bearings have thermo-couples placed in the bottom shells and the reading of the dial at once reveals any hot bearings. On the log sheet are noted any unusual sounds, temperatures, etc., in this way trouble can be detected early. If the engine is overhauled or any adjustment made, notation of the event is entered on the log.

In establishing a plan of maintenance, we made a schedule of adjustment which called for the removal of all four pistons once every six months but now believe once a year is ample. Some plants pull a piston every three months, so that in a year all are pulled once; the better plan is to pull all the pistons at the same time. It is possible to shut down Saturday at noon, go home and return at 6 p. m. when the engine is cool. By working all night the four pistons can be pulled, rings cleaned, connecting rod bearings adjusted and the parts put back by, say, 6 a. m. Sunday. Since this is done only once a year, the men are quite willing. If but one piston is pulled the men will dally around and take just as much time.

VALVES AND BEARINGS REQUIRE ATTENTION

Admission valves are removed every eight months and the exhaust valves every four months. The fuel valves are also examined every four months. Possibly with clean oil once every nine months is ample but our fuel is 22 deg. Baume and is often dirty. After 4 yr. of service, the main bearings have not been renewed. We check the wear once a year and remove enough shims to make the top clearance correct. The lower shells wear unevenly and this is corrected by scraping, using a micrometer to make the shell thicknesses all the same.

Our circulating lubrication system has a centrifugal and a gravity oil purifier. The oil passes continuously through the filter bags of the gravity filter and once a week we run the centrifugal to eliminate water, etc. It is my opinion that both should be run continuously with a bypass.

Contrary to expectations the air compressor has caused but little trouble. So far only two valves have broken and no carbon exists, due to our following the builder's instructions as to the amount of oil to be fed the compressor.

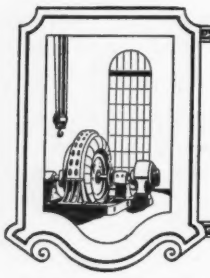
Duties in a Diesel plant are not as numerous as those of a steam plant but require a greater amount of care and judgment on the part of the men. Only a high-grade steam engineer will ever make a good oil engine operator. Operating engineers should study the oil engine; it is by no means mysterious—but a man needs more than a license to run one. He needs good judgment and a mechanical sense of values—but doesn't a steam engine deserve the same?

*Abstract of a paper presented during Oil and Gas Power National Conference, April 16-24, 1926.

McIntosh & Seymour Builds 2700-hp. Diesels for U. S. Ships

IN THE article appearing under this heading in the May 15 issue, page 610, the last two paragraphs were inadvertently taken from another article which has no relation to the tests conducted on the McIntosh & Seymour engines. Readers are requested to cross these paragraphs out of their copies of the magazines in order to prevent any wrong impressions regarding the engines which were tested.

FOR THE YEAR ENDED December 31, 1925, the annual report of Standard Gas & Electric Co., just issued, shows that the period was a marked success from an operating and earnings viewpoint. The principal new companies acquired during the year were Coast Power Co., Natrona Power Co., Consumers Light & Power Co. (in Oklahoma), St. Paul Gas Light Co., Wisconsin Public Service Corp., The California Oregon Power Co. and Standard Power & Light Corp. The present scope of the Company's system is illustrated in the four-color map accompanying the report. Total output of electric energy for the year was 1,970,643,085 kw-hr., an increase of 10.67 per cent; total gas output was 26,111,868,000 cu. ft. an increase of 9.53 per cent.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Modern Methods of Winding Armatures

A Description of the Two Most Common Types of D.C. Armature Windings. By Charles G. Green*

IN A PREVIOUS article which appeared in the March 15 issue of this magazine, the writer attempted to explain briefly the theory of using interpoles in generators. The only armature shown there was the old type ring wound armature which is almost obsolete but was given for simplicity of illustration.

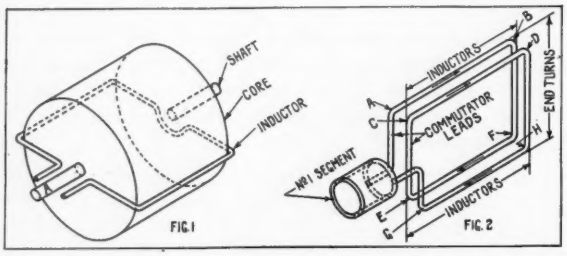


FIG. 1. DIAGRAM OF A SIMPLE DRUM WOUND ARMATURE
FIG. 2. A TWO-TURN ARMATURE CONNECTED TO A TWO-SEGMENT COMMUTATOR

In the following paragraphs the writer has endeavored to show the more modern armature construction together with the theory as it concerns the practical maintenance man's requirements.

In the ring wound armature it will be recalled that we utilized only one side of the entire coil of wire for the generation of voltage.

If, instead of having the armature made in the form of a ring, we make it in the form of a drum to rotate between a north and south pole of the machine, we can wind a coil of wire on it, either once around as shown in Fig. 1, or we can put more turns in series and get a higher resultant voltage by winding the wire around several times before cutting it by permitting the voltage of one turn of wire to add to that in the next turn. Two turns of wire are shown in Fig. 2 with the ends connected to a two segment commutator. In Fig. 2, it will be seen, one end of the coil is connected to segment No. 1 and after making two complete loops, the other end connects to segment No. 2. The voltage generated from A to B, while passing under a field pole, will be the same as that generated from C to D. Suppose the rotation and field polarity to be in a direction such as to generate in A-B and C-D a voltage as shown by arrows. Then the opposite side of the coil will be under an opposite pole and the voltage will also be opposite, according to geographical direction, but will be the same in the wire, as it is from A to B as shown by arrows from F to E and H to G.

It can be seen by the foregoing that the only inactive part of the coil is that crossing the end of the drum, and we can obtain any desired voltage by the use of more turns of wire in the coil. The limit of voltage is the insulation and the space to wind wire.

So as to be able to have a minimum of air gap between the field pole and the iron of the armature, it is desirable to imbed the coils of wire down in the iron and to leave a good smooth surface of the armature to sweep past the field pole face.

If we wish to utilize all the space around the drum or armature, we can place just a few turns of wire in each coil and put several coils in a slot and by making the proper connections to a suitable commutator, we can have the voltage of one coil of a few turns add with the voltage of the next coil, and so on.

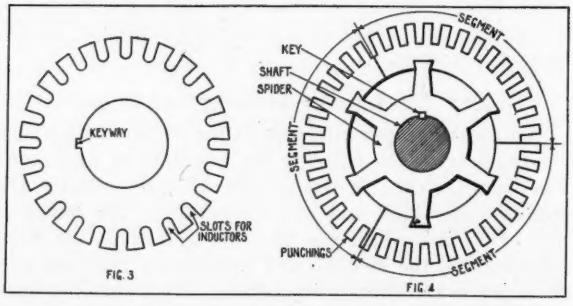


FIG. 3. ARMATURE PUNCHING OR LAMINATION FOR A SMALL MOTOR
FIG. 4. CROSS SECTION OF AN ARMATURE WITH SEGMENT PUNCHINGS

The armature of the drum type is built up of several hundred thin sheets of iron called laminations. These are punched out in the shape and size wanted before being clamped together. One punching or lamination with the slots for holding the coils in place is shown in Fig. 3. The punching is made for a certain sized shaft and the key way punched just as are the slots for the inductors.

In the large sized armatures, where it is not practical to punch from such large sheets of iron as would be necessary, the laminations are made in parts called segment punchings and arranged on a spider which is

*Instructor in Motor Department, Coyne Electrical School.

mounted on the shaft, as shown in Fig. 4. The different layers are staggered so the divisions between segment punchings will not weaken the structure when these laminations are built up into a drum type armature and placed in the influence of the magnetic field. Figures 5A and 5B show how the flux is distributed through the field structure and armature. In Fig. 5A the flux travels through air from a north pole to a south pole and does not have any definite place to leave or enter the poles. While with the armature in place, the flux leaves directly from the face of the north pole and enters the face of the south. It can be seen by this that if we have the inductors in the slots as shown by the black dots, they will be forced to pass through the dense magnetic field and by having the coils wound so one side of a coil is under an N pole while the other side is under an S pole, the voltages generated in the respective coils will add as in Fig. 2.

By having four poles the distance from an N pole center to an S pole center will be less and we will waste less copper across the back and front of the armature. Also, we can generate the desired voltage with a lower speed of rotation. As one side of a coil must be under an N pole while the opposite side is under an S pole, it is evident that regardless of the number of poles the coil sides must be separated far enough so that at no instant will the two sides of a coil be under the poles

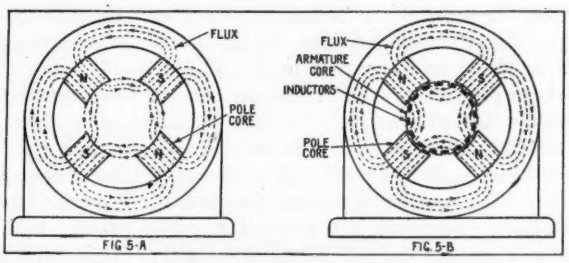


FIG. 5-A AND B. DISTRIBUTION OF MAGNETIC LINES OF FORCE IN THE FIELD STRUCTURE OF A GENERATOR WITH AND WITHOUT THE ARMATURE

of the same polarity. This means that the span of each coil must be approximately from center N to center S or as shown by angle A, Fig. 6, from one neutral plane to the next, which is almost the same as angle B, which is the angular pole pitch and represents 180 electrical degrees. Angle A is called the angular pitch or spread of the coils, or winding pitch.

When any one coil side moves from the center between an N and S pole past a complete N pole and an S pole, we have what is called one complete cycle or 360 electrical degrees as at angle D, Fig. 6.

It must be understood that there are a great number of possible types of winding. But in the direct current machines there are only two types which are used extensively, namely, lap winding, sometimes called parallel or multiple drum winding and also the wave winding, sometimes called two-circuit series drum winding. Each of the foregoing are also divided into several types, which will not be described here.

The lap winding is far more common in low voltage work than the wave winding. It has the advantage of simplicity which is a great point to its credit. It is, however, not adapted to the generation of high voltages as can be seen by a careful study of the two diagrams explaining it in Figs. 7A and 7B, the first being what is known as a plane development, which represents the winding as it would appear if it were unrolled from the core and laid out on a flat surface and Fig. 7B, known as a star development, which is in a way what might be expected to resemble the winding if it was stripped from the iron core and pressure applied along its axis and flattened out.

In the plane development Fig. 7A we have a lap winding four pole. There are 18 inductors or coil sides which make up 9 coils. These are shown in their simplest form so as to show the principle of such a winding without spending any time on complications.

With the direction of rotation or motion of the coils as shown by arrows, the brushes and pole pieces sta-

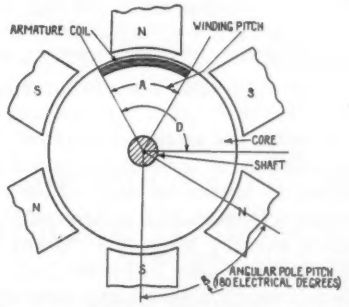


FIG. 6. DIAGRAM TO SHOW THE SIGNIFICANCE OF TERMS USED IN ARMATURE WINDING

tionary, it is evident that there will be a voltage generated in all wires or coil sides while passing over the surface of a pole. One thing to remember in tracing this circuit through is that the individual voltages induced in the respective coils connected together are added, so as to produce a high resultant voltage. If the winding is traced out starting at No. 1, we find by the use of Fleming's right-hand rule that the voltage will be as shown by arrow. Now, by reference to the opposite end, we find 17 will be generating a pressure or voltage so as to produce a pressure in 4 which is out of the magnetic field.

The heavy arrows indicate the voltage generated and the light arrows along the face conductors show the nature of current flow due to the voltage generated in the active coils. Where the voltage of any two coils or more is directed toward a segment where the two are connected, or where these voltages are directed both away from the segment, we must place a brush. Where the two are directed toward the segment as at A and A_1, Fig. 7A, it is called a positive brush and marked with the symbol +. Take positive brush A and we find it has the pressure of coil sides 5-10-7 and 12 directed toward it and added in series. Also, we have the pressure from 16 and 11—14 and 9 toward it. The opposite end of the former set terminating at negative brush B and the opposite end of the latter set terminating at brush C. We also find coil sides 8 —3 —6 and 1 directed toward positive A_1 and the opposite or negative end of these coils terminating at negative brush B, also coil sides 13 —18 —15 —2 —17 and 4 are directed toward positive brush A_1 and the negative end terminates at negative brush C.

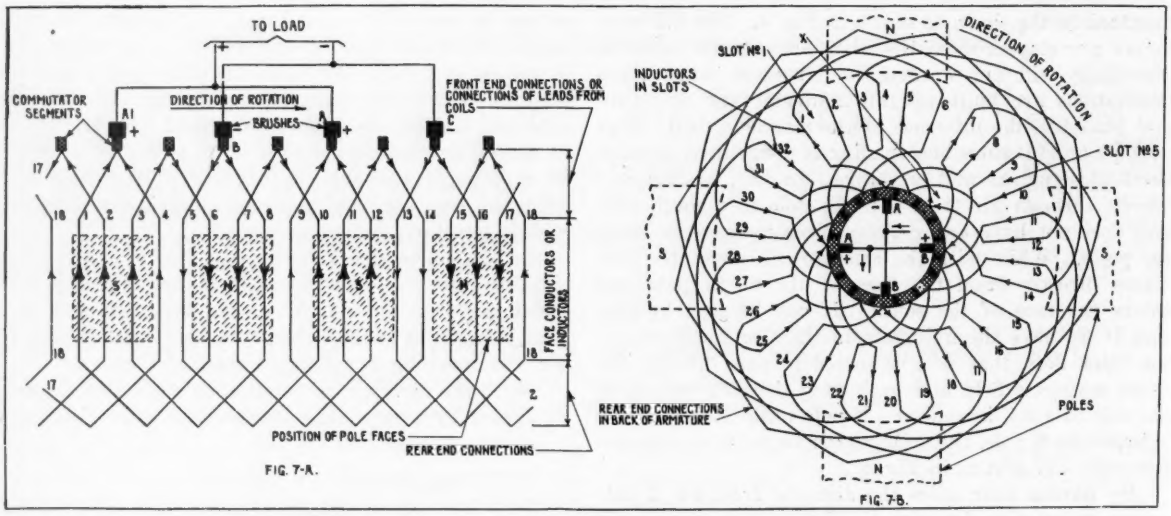


FIG. 7 A AND B. PLANE AND STAR DEVELOPMENTS OF LAP WINDING

So as to equalize the amount of current throughout the armature winding, it is necessary to tie all positive brushes together as shown by dotted line and also all negative brushes. Thus we find several paths or circuits in the armature winding where the current may travel —as many as there are poles. It is evident then that at no one place will we have very many coils in series and unless each coil is made up of a great number of turns of wire the voltage generated will be relatively low.

It will also be noticed that, due to placing all brushes directly on a segment for simplicity instead of showing some of the brushes shorting two segments as they pass from one to the next, the number of coils feeding each brush comes out uneven as on negative C and positive A_1.

Referring to the star diagram, Fig. 7B, and by tracing from negative brush A we find the current has two paths, one back toward the rear of armature through No. 1 inductor, the other back along No. 8 inductor. Again at negative brush B, we have the two paths through No. 24 and No. 17. Each one of these four paths head either toward positive brush A or negative brush B.

Tracing the circuit from negative A we find that all the voltages of the following coil sides would be in series and all these voltages would add, starting back through No. 1 across the back of the armature and forward through No. 10 connected to a segment with No. 3 and continue to No. 12 —5 —14 —7 —16 where positive brush B takes the current to be sent out on the line.

From negative brush A we also pass through No. 8 —31 —6 —29 —4 —27 —2 —25 and positive brush A joins with positive B to send the current out on the line. Paths in series will add the voltage while parallel paths give a greater current carrying capacity. It is evident then that the voltage of the entire machine will be equal to the voltage of any one path or the same as the voltage if measured from negative to positive brush.

The circuits starting from negative B will trace in

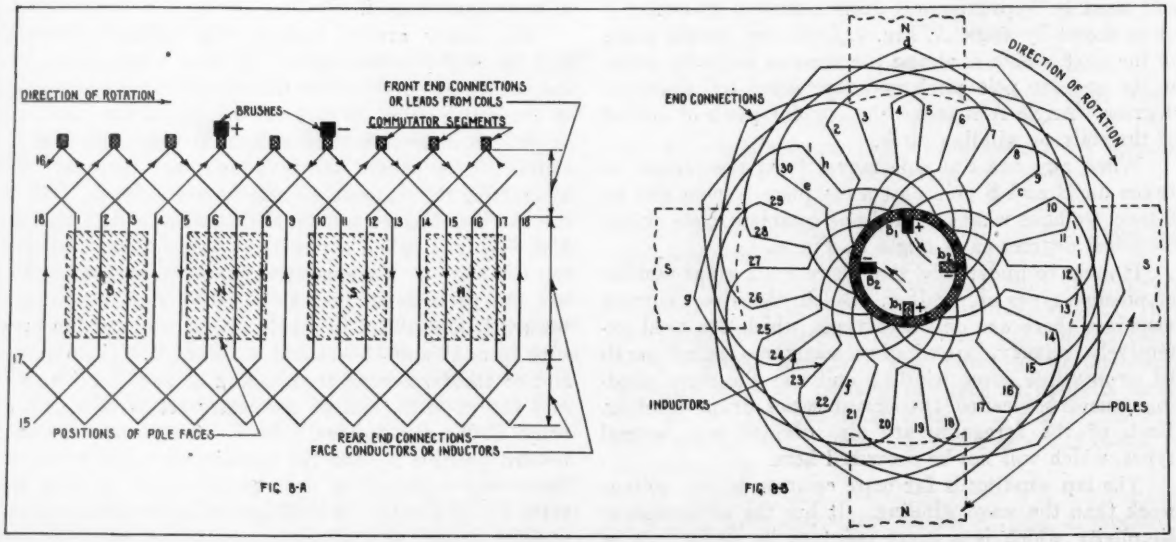


FIG. 8 A AND B. PLANE AND STAR DEVELOPMENTS OF WAVE WINDING

the same manner as the other half of the winding. It should be understood that in actual practice, we do not have a separate slot for each coil side but in the simplest windings we have two coil sides per slot such as coil side No. 1 and 2 will be in one slot, No. 3 and 4 in the next, etc. The winding pitch, Fig. 6, or as commonly called the "coil throw" will be slot No. 1 to 5, because one side of a coil is in No. 1 and the other side of the same coil is in No. 5 slot.

Notice that the brushes are placed on segments where the voltage is all either toward or away from the segment and not as shown at X, where it is both toward and away.

It can be seen that, as shown in Fig. 7C, if the voltages around the armature are in the general direction shown that if any one of the brushes was lifted from the commutator, say positive B, the voltage from one-fourth of the armature would neutralize the voltage from another one-fourth, leaving only one-half of the

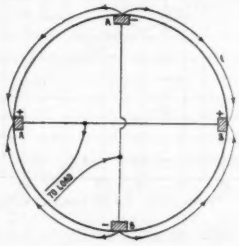


FIG. 7 C. DIAGRAM TO SHOW DIRECTION OF CURRENT IN A LAP WOUND ARMATURE

armature in operation and although the voltage would still be approximately the same, the current carrying capacity will be cut in half. This is not so with the wave winding as will be pointed out later.

Wave Wound Armatures

The wave winding is used for direct current, drum armatures, where the lap winding will not provide a sufficiently high voltage unless wound with an excessive number of turns of wire per coil or an excessive speed. By tracing the circuit, Fig. 8A, from negative brush we pass from pole to pole through the windings in a wave action. The path of the conductor is back under an N pole, forward under the S pole, then back under the next N, and so on. In this way the voltages in the separate inductors, although being opposite under each pole, will always add.

In tracing we find we have a great number of coils in series, thus producing a high voltage. At only two places on the commutator is the voltage either all directed toward or away from the segment, consequently, only two brushes are needed regardless of the number of poles, although more can be put up to the number of poles if desired to carry heavy currents, by simply placing extra brushes b_1 and b_2 in other neutral planes, Fig. 8B.

Tracing from negative brush we have two paths only, one path 8 —3 —16 —11 —6 —1 —14 —9 to the positive brush, and another from negative brush through 13 —18 —5 —10 —15 —2 —7 —12 —17 —4 to the positive brush. The unbalance comes from setting the brushes directly on segments for simplicity.

By referring to Fig. 8B, we find by tracing the circuit we start at the negative brush and we have one circuit or path through coil sides 30 —9 —16 —25 —2 —11 —18 —27 —4 —13 —20 —29 —6 —15 —22 —1 and to the negative brush and the other circuit from negative brush will be 23 —14 —7 —28 —21 —12 —5 —26 —19 —10 —3 —24 —17 —8 to the positive brush, thus giving two circuits in parallel with the wave while we had four with lap. With half as many circuits with wave there are twice as many coil sides or coils in series giving approximately twice the voltage for wave as for lap, if other conditions, such as coils, turns per coil, field strength and speed, remain the same.

The addition of more brushes, such as b_1 and b_2 in the remaining neutral planes will not affect the voltage because the added brush b_2 is, at the instant shown, connected through a low resistance path of only one coil, that is, it is approximately the same as if B_2 and b_2 were one and the same brush. The low resistance path connecting the other two brushes is b_1 —f —g —h —B_1. If desired B_1 and B_2 could be taken off and b_1 and b_2 used or, if it was a machine with six or more poles, any positive and negative brush could be used.

Simultaneous Loading of 2-Voltage Transformers

By E. P. Wimmer*

OPERATING companies often find it convenient to use a transformer which is delta-connected on the low voltage side, to deliver simultaneous loads from the full-voltage and half-voltage taps. In order to do this safely it is necessary to determine the relationship between these loads; otherwise the transformer may be overloaded, with resultant burn-out and interruption of service.

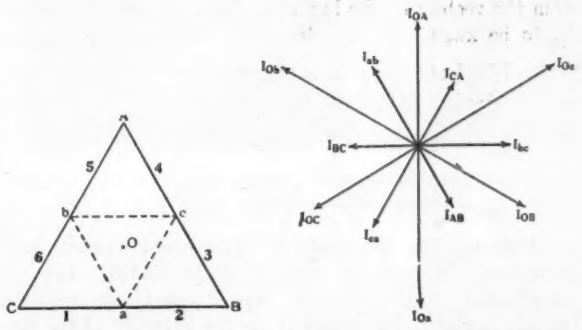


FIG. 1. SCHEMATIC DIAGRAM OF DELTA-CONNECTED TRANSFORMER SECONDARY WITH HALF-VOLTAGE TAPS

FIG. 2. VECTOR DIAGRAM OF LINE AND WINDING SECONDARY CURRENTS

For 50 percent load on A-B-C and 32.5 percent load on a-b-c, both loads being at the same power-factor

In this analysis, both loads will be considered as balanced and at unity power-factor, although the same results will hold for any power-factor provided that both loads are at the same power-factor. Figure 1 represents schematically the delta-connected secondary of a three-phase transformer. Loads are delivered from A-B-C and a-b-c. The magnitudes and phase relations of line currents and winding currents for the case of 50 per cent load on A-B-C and 32.5 per cent load on a-b-c, are shown in Figs. 2 and 3.

*Transformer Engineering Dept., Westinghouse Electric and Mfg. Co.

The point O is the hypothetical neutral of the delta. I_{OA}, I_{OB} and I_{OC} are the full-voltage line currents and their component winding currents are I_{AB}, I_{BC} and I_{CA}. For the half-voltage taps the line currents are I_{Oa}, I_{Ob} and I_{Oc} and the component winding currents are I_{ab}, I_{bc} and I_{ca}. The dotted lines ab, bc, and ca are merely to indicate the inside delta and not an actual electrical connection. The winding current I_{ab} for example, although having the magnitude and phase direction shown in Fig. 2, actually follows the path aCb. It is evident that the current in any portion of the secondary winding is the vector sum of the two component currents in that winding due to the two loads. For example, consider section 1. The current flowing in it is the vector sum of I_{BC} due to

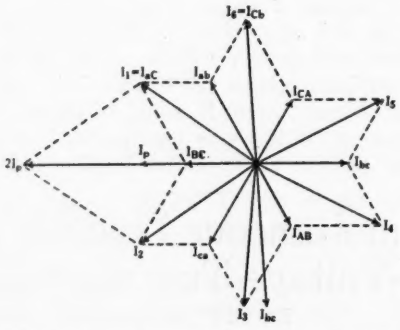


FIG. 3. DETERMINATION OF RESULTANT SECONDARY AND PRIMARY WINDING CURRENTS

the load on A-B-C, and I_{ab} due to the load on a-b-c or,—

$$I_1 = I_{ab} + I_{BC} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

As I_1, the current rating of the winding, is always known, with one load current given the other can be determined from the vectors by the law of cosines. In Fig. 3, assume I_{ab} to be known and I_{BC} to be determined. Then,—

$$I_1^2 = I_{ab}^2 + I_{BC}^2 - 2I_{ab}\, I_{BC} \cos 120^0$$

$$I_1^2 = I_{ab}^2 + I_{BC}^2 + I_{ab}\, I_{BC}$$

$$I_{BC}^2 + I_{ab}\, I_{BC} + \frac{I_{ab}^2}{4} = I_1^2 - \frac{3I_{ab}^2}{4}$$

$$I_{BC} = \sqrt{I_1^2 - \frac{3I_{ab}^2}{4}} - \frac{I_{ab}}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Although the secondary is fully loaded under these conditions, the primary may be under-loaded. Let the transformer in the example have a one-to-one ratio of transformation. The current in the primary phase corresponding to BC will be half the vector sum of I_1 and I_2. Thus, in Fig. 3,

$$I_p = \frac{I_1 + I_2}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Evidently it is less than either of its components, so that, although the secondary is fully loaded, the primary carries only a fraction of full load. The same conclusion holds for the other phases. Curves for determining the magnitudes of simultaneous loads at full and half voltage, with the secondary always fully loaded, are shown in Fig. 4. It is interesting to note that when only the mid-taps a-b-c are employed, the maximum load obtainable is one-half normal; however, as the primary winding under this condition is carrying only half normal current, this load may be increased somewhat due to temperature considerations.

The chart, Fig. 5, is convenient for determining current values for different loads. The radius of the arc (shown dotted) represents the magnitude of the secondary full-load current. Its components are the full-voltage and half-voltage load currents at an angle of 120° with each other, when both loads are at the same power-factor. As an example, when taking 50 per cent of normal load current from A-B-C, the chart shows that 65 per cent of normal load current can be taken from a-b-c. This is

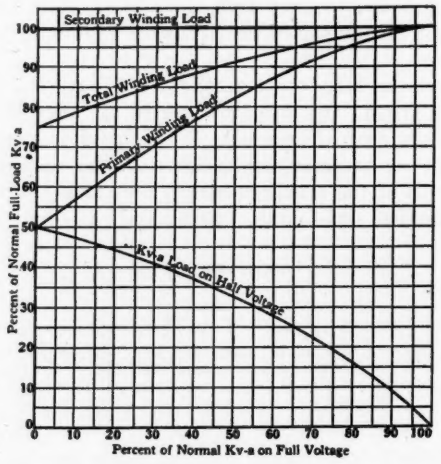


FIG. 4. CURVES FOR SIMULTANEOUS LOADS AT FULL AND HALF VOLTAGE

On the delta-connected secondary of a three-phase transformer, with both loads at the same power-factor and the secondary winding fully loaded.

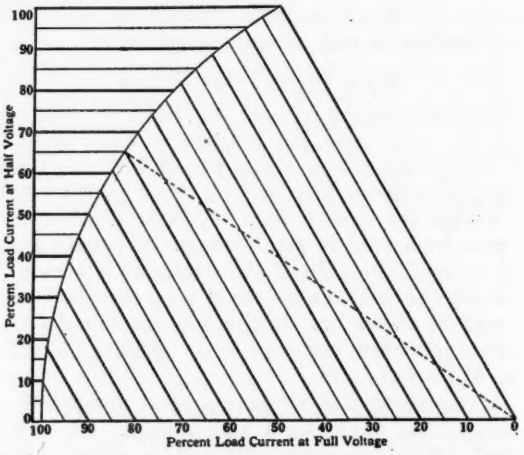


FIG. 5. CHART FOR DETERMINING SIMULTANEOUS CURRENTS AT FULL AND HALF VOLTAGE

With the delta-connected secondary winding fully loaded and both loads at the same power-factor

32.5 per cent of normal kv.a. load, which checks with the curve in Fig. 4.

Example—A 100 kv.a. three-phase transformer, 2300 v. delta high voltage to 230/115 v. delta low voltage, delivers 50 kv.a. three-phase, at unity power factor, 230 v. Then from the curve in Fig. 4 we see that 32.5 kv.a. three-phase, at unity power-factor, may be taken from the 115-v. taps without overloading the low-voltage winding. —The Electric Journal.

Power for the Western Electric Co. at Kearny

NEW FACTORY FOR THE MANUFACTURE OF TELEPHONE EQUIPMENT IS SERVED BY A POWER PLANT WHICH EMBODIES THE MOST MODERN FEATURES OF POWER PLANT CONSTRUCTION

MADE WITH the same care that is used in the manufacture of telephone equipment, the new power plant for the new Kearny works of the Western Electric Co., at Kearny, N. J., ranks among the finest examples of industrial power plant construction to be found in this country. This plant which is to serve the new telephone equipment and cable factory is located at the southeast corner of the 55-acre tract near the dock line of the Passaic River. The buildings are of steel frame and pressed brick construction on pile and concrete foundations and harmonize architecturally with the adjacent factory buildings. They consist of a main boiler and turbine building and a coal receiving and ash storage building which is located just west of the main building and connected to it by an overhead bridge. There is also a two-story drag scraper operating house south of the main building. The buildings have been designed to house the ultimate service requirements and now contain equipment for the initial development. All commodities, such as electricity, refrigerated drinking water, compressed air, hot water, etc., with the exception of battery charging current, are delivered to the industrial building group through two commodious concrete tunnels.

COAL AND ASH HANDLING EQUIPMENT

Coal may be received in cars, by barge and by truck. All coal drops into concrete hoppers under the two railroad tracks in the coal and ash buildings from which it is fed by two reciprocating feeders through two crushers into two 85-t. Peck continuous bucket carriers, which elevate the coal to an 820-t. concrete bunker over the firing aisle. From here it is fed by gravity through steel pipe and steel plate hoppers to the stokers. The south conveyor can also discharge its contents into a chute which delivers the coal to a hopper platform located just outside of the southeast corner of the building, where it can be carried to storage by the drag scraper equipment. The latter is also used for reclaiming. The reclaim equipment has a capacity of 60 t. per hr. and the area available to store coal a capacity of about 300,000 t. All conveyor and crusher equipment is electrically driven and with the exception of the Peck carrier which was made by the Link-Belt Co., was furnished by the R. H. Beaumont Co.

Ashes drop directly into a 1275-cu. ft. brick-lined hopper below the respective boiler setting, and discharge through water operated slide gates directly on to the Peck carriers which deliver them to an elevated concrete ash hopper of approximately 700-t. capacity.

STEAM GENERATING EQUIPMENT

Space is provided in the boiler room for eight boilers, 2000 b.h.p., set in batteries of two, in two rows, facing a center firing aisle. The four boilers and allied equipment forming the north half of the boiler room are now installed. The present boilers are Babcock & Wilcox Co. make, each having 7989 sq. ft. of heating surface, and are designed for a working pressure of 300 lb. Each boiler has a B. & W. Co. superheater of 1000-sq. ft. surface, to provide 200 deg. F. superheat. Liberal combustion space has been provided in the high settings to permit a maximum output of over 2000 b.h.p. each. The fuel used is preferably No. 3 anthracite buckwheat, and is burned on Coxe forced-draft chain grate stokers, each stoker having total grate area of 195.6 sq. ft. and driven at the rear by 120-v. direct-current variable speed motor. Three separate chambers permit close regulation of air to fire. Air is furnished to the stokers

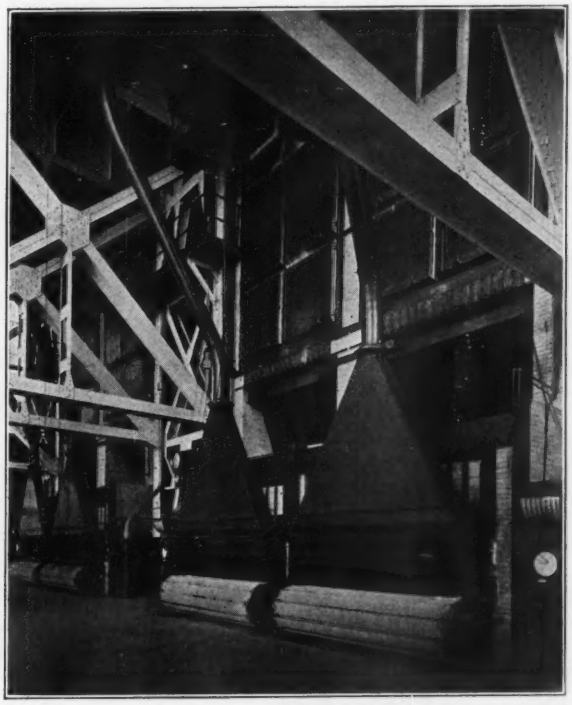


FIG. 1. VIEW IN THE BOILER ROOM AT THE KEARNY PLANT OF THE WESTERN ELECTRIC CO.

by four Sturtevant fans each with a capacity of 35,000 c.f.m., which are driven by four 40-hp. motors. All fans discharge into a steel plate air header duct which connects directly to the individual windboxes of each stoker. Space is provided for duplicate fan equipment for the future south row of boilers. Liptak suspended arches at front and back of each stoker provide for ignition and mixing of gases and Bernitz carborundum blocks inside the walls at the stoker line minimize slag formation at these points. The center wall of each battery is of special ventilated construction. The brick settings were installed by Ballard-Sprague & Company.

Each boiler has six Diamond Power Specialty soot blowers, and the feed water piping includes Copes regulators. Combustion conditions are indicated by Bailey boiler meter, and illuminated dial air pressure gages for each windbox. The steel plate breeching which is located at rear and above the boilers is the Connery expansion stiffener design, and discharges into the bottom of an Alphons-Custodis radial hollow brick stack

12 ft. 6 in. in diameter and 200 ft. high, supported on the building steel. The top of the stack is 258 ft. above the grates. Space is provided in the building design for future economizers under each stack. The breeching is lined throughout with 2-in. Johns-Manville fire-backing insulation.

Superheated steam is transmitted by 7-in. leads from each boiler to the 14-in. main header. There are two auxiliary high-pressure headers, one 10 in. in diameter feeding two Ruggles-Klingemann 4-in. reducing valves for the 90-lb. industrial steam line to factory; one 1½-in. reducing valve for lower pressure live steam to small station auxiliaries; a 4-in. line to fire pumps; and a 6-in. reducing valve for 2-lb. steam direct to low pressure header through 12-in. pipe loop. The other header is 6-in. in diameter and feeds the steam driven boiler feed pumps and exciters. All high pressure lines have Sargol joints and all valves are Chapman cast steel with monel metal trim. Most of the large valves are motor driven with Dean control, many being controlled from two positions.

Boiler feed water is heated by one Elliott, type M, deaerator heater, having a capacity of 150,000 lb. of water per hr. There are two Alberger, 4-stage, centrifugal feed pumps, each having a capacity of 400 g.p.m. at 355 lb., driven by two Sturtevant, 150-hp., non-condensing steam turbines. These units are located on the turbine room floor and pump into two independent feed water mains, connected to independent feeds at each boiler. The condensate from the turbines discharges into a header which returns the water direct to the heater. Overflow from the heater is conducted by gravity through a seal to a hot water tank under the turbine room floor. This tank also receives the condensate return contents from the shop steam system, and the hot water is raised again into the heater by a 4-in. Crane 3-valve tilt trap.

Electric Generating Equipment

The turbine room is divided into three east and west bays. The main center bay is 45 ft. wide with an overhead 30-t. Shaw electric travelling crane, and has space for four 5000-kw. turbo-generator units, and one 1500-kw. unit. The south bay is 22 ft. wide with a 20-t. Shaw electric travelling crane, and has room for three boiler feed pumps, three exciters, and two 1500-kw. turbo-generator units. The north bay, 22½ ft. wide, contains the switchboard and electric switching and outgoing feeder equipment, and below on the basement floor, is space, served by a 5-t. hand-power travelling crane, for five motor driven air compressor units, one of which is now installed. The west end of this air compressor space now contains the electric locomotive and crane battery charging equipment. Two reinforced

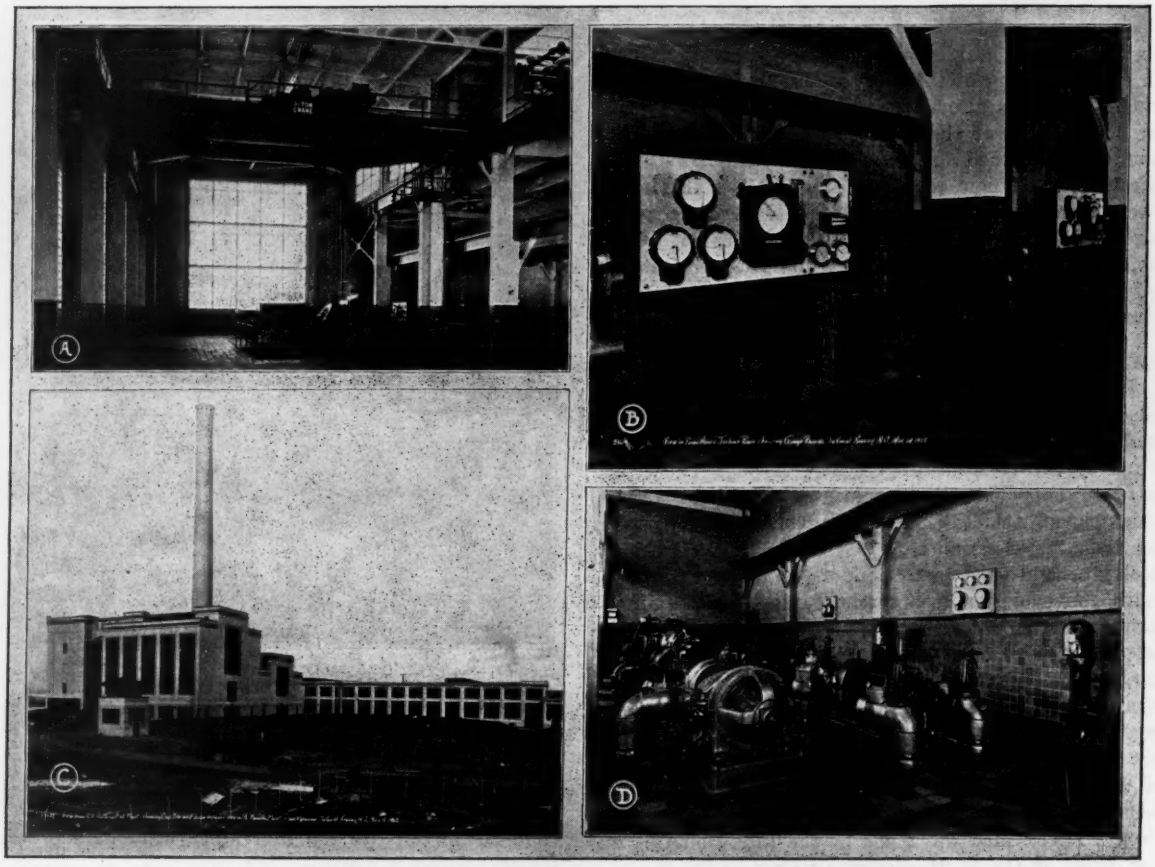


FIG. 2. AT THE NEW KEARNY PLANT OF THE WESTERN ELECTRIC CO.
A. The turbine room. B. Gage board in the turbine room. C. An exterior view of the plant showing coal pile and drag scraper house in foreground. D. Exciters and feed pumps, the latter connected to two independent feed mains.

concrete tunnels beneath the main bay basement floor convey cooling water to and from the turbine condensers. There is a duplicate motor-driven travelling screen equipment in a room in the west side of the building which takes care of the trash problem.

At present the main generating equipment consists of:

1—1500-kw. non-condensing turbo-generator;
1—1500-kw. combined condensing and automatic extraction and induction turbo-generator; and
1—5000-kw. condensing turbo-generator;

all of General Electric make. The steam turbines are designed for steam at 275-lb. pressure and 200-deg. F. superheat. The mixed pressure machine automatically regulates itself at 2-lb. back pressure and the 1500-kw. non-condensing unit discharges directly into the station low pressure header.

The 1500-kw. mixed pressure unit has an Alberger present heater located at the basement level is a Wainright unit of the cast shell vertical type, of 2970 sq. ft. of heat surface, capable of heating 3000 g.p.m. from 170 deg. to 200 deg. F., with steam at atmospheric pressure. Space is available and piping is designed for three additional units of same type and capacity. The water is circulated by a 4000-g.p.m. Alberger single-stage, 1200-r.p.m. centrifugal pump, at 35-lb. pressure, direct-connected to a 150-hp. motor and space is available for two additional similar units. The entire system has static pressure head of 120 ft. Condensate from the heater is now handled through a 4-in. Crane 3-valve trap direct to the hot water heater.

Compressed Air, Steam and Refrigeration for the Factory

Compressed air is now furnished by one 1300-cu. ft. 14 and 22 by 16-in. Ingersoll-Rand, 2-stage compressor,

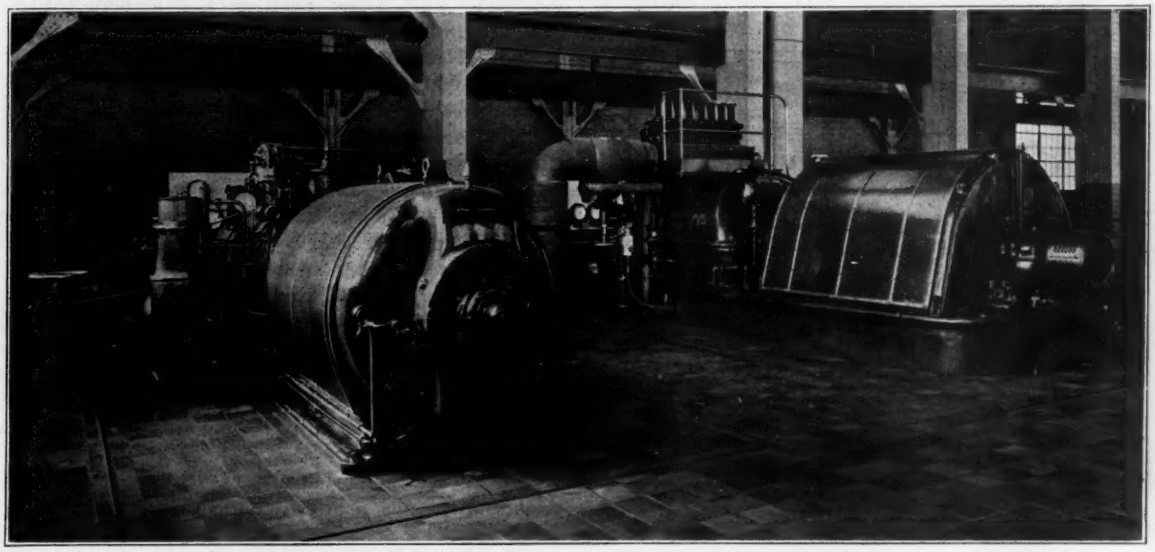


FIG. 3. THE TURBO-GENERATORS, 1500-KW. UNIT AT LEFT, 5000-KW. UNIT AT RIGHT

Spiro Flow surface condenser with steam ejector, and after-condenser equipment, with one 12-in. Alberger circulating pump, driven by a 20-hp. motor; and two 2½-in. Alberger, type N, 1800-r.p.m. condensate pumps, each driven by a 10-hp. motor. The 5000-kw. unit has an Alberger Spiro Flow surface condenser capable of producing 28-in. vacuum at full load. The circulating water and condensate pump equipment of this unit is in duplicate. The dry vacuum equipment is of the Alberger steam ejector type, complete with after-condensers. Each circulating pump is a 12-in. Alberger, 900-r.p.m. centrifugal unit driven by a 30-hp. motor. Each condensate pump is a 3-in. Alberger, 1800-r.p.m., centrifugal unit, driven by a 20-hp. motor.

Each turbine unit with condenser is supported on an independent steel foundation. Each generator has an independent General Electric enclosed air cooler equipment with recording thermometers to indicate the temperature of air and cooling water in and out from each unit.

The entire Kearny plant, including the power house, is heated by a forced hot water circulating system. The direct-driven by a General Electric 260-hp., 225-r.p.m. synchronous motor.

Steam for industrial purposes is supplied at approximately 90-lb. pressure through duplicate Ruggles-Klingemann valves with each unit having thermostatically controlled dehumidifier.

A feature somewhat unusual for industrial plants is the refrigerating equipment for drinking water service. This is located in the basement and is complete for the ultimate development. This equipment includes:

1—York 10 by 10-ft., 2-cylinder, single-acting ammonia compressor, direct-driven by a 75-hp., 164-r.p.m. synchronous motor;
1—ammonia condenser;
1—cooling tank, 22 ft. by 4 ft. 6 in. by 7 ft. 6 in., with float controlled make-up, and having 4800 ft of 1¼-in. cooling pipe;
1—78-in International filter with capacity of 100 g.p.m.; and
2—2-in., 2-stage, type N, Alberger centrifugal circulating pumps, each of 65-g.p.m. capacity.

This equipment was installed by the Shipley Construction & Supply Company.

Oil is cooled and filtered by a Richardson-Phenix oil filtering and continuous circulating system.

A number of cooling water discharges are brought to a central 1650-gal. tank located directly below the hot water tank. The contents of this tank are raised by one of two 2-in. Alberger, 100-g.p.m. motor-driven pumps to a 6400-gal. elevated surge tank located under the roof of the boiler room, from which make-up water to heater is drawn. Overflow from the surge tank returns by gravity to the cold water tank which has an overflow to the sewer, and also has float-controlled city water make-up through a regulating valve. All the water used, except for circulating in condensers, is from Kearny city water supply.

Fire protection equipment consists of two units each of 1500-g.p.m., Lecourtenay Underwriters centrifugal pumps of 100-lb. pressure, direct-driven by a Sturtevant, 150-hp. steam turbine. This latter supply is

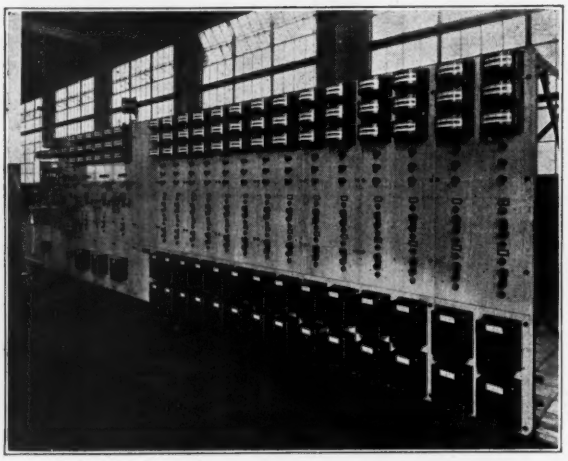


FIG. 4. MAIN CONTROL BOARD AT KEARNY

through a 16-in. pipe immersed in the circulating water discharge tunnel, and has an Elliott twin strainer. This line is primed by a Penberthy injector in less than one minute.

Electrical Equipment

A feature of special interest is the arrangement of the electric switchboard and control equipment. All power is generated and distributed as 3-phase, 60-cycle, 4-wire, and at approximately 460 v. Although this requires a very heavy investment in copper and heavy switches, its use eliminates all transformers and attendant fire and life hazards throughout the plant. The main control board is located in the north bay of the turbine room and ultimately will be symmetrical with respect to the north and south center line of the building. It is 90 in. high and of 2-in. Blue Vermont marble. At present it consists of:

1—regulator panel;
1—generator-winding temperature-indicating panel;
1—115-v. d. c. panel for 2 exciters;
3—generator panels; and
6—4-circuit feeder control panels.

All of the generator main and feeder circuit switches are remote controlled air break type. The generator and feeder switches are located in a mezzanine balcony below the turbine room floor. The feeder switches are each of 500-amp. capacity, and are mounted two on each Monson slate panel. Each feeder circuit has direct-current solenoid relay, and three alternating-current overload relays. Each circuit also has three air-cooled reactance coils which connect to the lead-covered, paper-insulated 250,000-cm. feeder cables (two cables per circuit), which are neatly racked to steel frames beneath the mezzanine floor and extend out through two tunnels. All feeder cables are run open on racks in tunnels and in building basements, and in iron conduits only where they rise to distributing centers throughout the factory. The lead sheath of the cables is used for the grounded neutral conductor. Space is provided for a total of 52 2-circuit feeder panels, of which 16 are now installed. Each feeder circuit has integrating watthour meter and switching equipment to provide indicating watt meter readings and ampere readings per phase. The generator main switches are mounted on 2-in. Monson slate panels attached to 2½-in. heavy maple frames, specially designed to withstand the operating shocks. Generator leads and buses are of ¼ by 4-in. copper bars, each phase arranged to minimize skin effect. Each phase is isolated by ½-in. transite board baffles. The main generators are excited by 120-v., d. c. supplied by a 75-kw. direct-connected exciter driven through a reducing gear by a General Electric single-stage, non-condensing steam turbine. There are two of these units, either of which will furnish excitation for all turbines while the other is used for the small amount of direct current required for the variable speed stoker motors, and a few direct-current motors in the Cable Plant buildings. A third 75-kw. induction motor-driven, direct-current exciter unit is being installed as a spare for either service.

All of the motors in the plant, except the stoker motors, are 3-phase, alternating-current type. The air compressor, ice machine, and battery charging set motors are of synchronous type. The balance of the motors are of induction motor type, and all motors are Western Electric.

Excavation, piling, and foundation concrete work were done by Henry Steers, Inc.; the Turner Construction Company were the general contractors on the super-structure building work; and J. Livingston & Company, Incorporated, were the general contractors for the mechanical and electrical equipment.

Engineering design and supervision of construction were carried out under the direction of the Engineer of Plant of the Western Electric Co., Incorporated, by the J. G. White Engineering Corporation.

Duke-Price Power Co., Ltd., Montreal, Que., organized to carry out the hydro-electric development on the Saguenay River, Que., has been acquired by the Aluminum Co. of America, and the Shawinigan Water & Power Co., the first noted securing majority control. The new owners will continue the power development work now under way at Isle Maligne, Que., as described in the September 15, 1925 issue of Power Plant Engineering.

Propeller Type Turbines May Have Too Great Suction Head

If Water Vapor Is Formed Under the Blades, Erosion from Water Hammer and Corrosion by Released Oxygen May Result

IN AN article in Engineering of London, Elov Eglesson calls attention to the consequences of setting the runners of Francis, propeller or Kaplan turbines at such height above tail-water level that the pressure on the undersides of the blades will be less than the vapor pressure of water. This will allow the water to leave the undersides of the blades and cavities filled with vapor will be formed. Three consequences will follow: 1. Output and efficiency of the turbine will be decreased because of eddy currents. 2. Runner blades and sometimes adjacent parts will be eroded and corroded. 3. Heavy shock and percussion will occur in the suction pipe, possibly so violent as to prevent operation.

Similar action has been observed with high-speed ship propellers and was reported in 1917 by a committee of the British Admiralty. Impact from the collapse of small or large cavities may result in pressures as high as 700 t. per sq. in. and these heavy blows erode the surfaces subject to impact or even stretch the metal by peening action so that blades are bent near the ends.

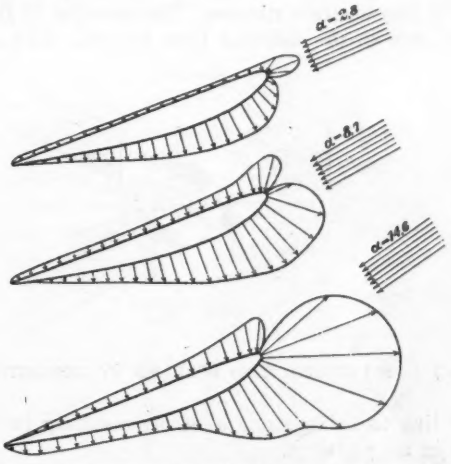
In many cases, corrosion and erosion of turbine runners has been stopped by using materials, such as special bronzes, which resist chemical action, although their strength was no greater than that of materials previously used.

Mr. Eglesson gives as the factors which influence cavitation the following: 1. Static suction head, increase of which increases danger of forming cavities. 2. Axial velocity of exit of water from the runner. The greater the velocity head to be regained in the suction pipe, the greater is the probability of cavitation under the blades. For propeller-type turbines, this velocity head is 20 to 30 per cent of the total head and for Kaplan turbines, 20 to 30 per cent at normal load, running up to 70 per cent at overload on high-speed runners. 3. Length of blade in direction of flow as compared to pitch. To keep down friction, blade length is made short compared to pitch around the wheel between like edges of blades. But this increases specific surface pressure and danger of cavitation. The greater the total and suction heads, the longer must blades be made in the direction of flow of the water and the lower must be the specific speed. Blades can be made with length greater than pitch but more than four blades should be used. 4. Angle between direction of water flow and blade surface at the inlet. In researches made by Dr. Betz at Göttingen, it was shown that increasing this angle, a, from 2.8 deg. to 14.6 deg. raised the greatest vacuum from an amount equal to the greatest pressure to an amount three times the greatest pressure, as shown in the sketch. Hence, the greater this angle, the sooner will cavitation occur.

Other factors, which are variable with conditions, are the shape of the blade, temperature of the water and peripheral speed of the runner. To determine the effect of these, a special laboratory has been installed at Verkstaden Kristinehamn in which runners up to 10 in. diameter can be tested at heads up to 36 ft. and for any desired suction head, positive or negative.

Description of the apparatus, which includes a centrifugal pump drawing from the suction chamber and delivering into a pressure chamber whence the water flows through a venturi meter to the turbine, is given but no results of tests. Load is applied by an Alden absorption dynamometer and a glass window and oscilloscope are used as a means of studying cavitation effects.

It has been found that the leakage between the ends of the blades and the guide wheel foot tends to draw the water away from the backs of the blades next to the clearance even at moderate heads and suction heads. A remedy has been to give the casing a spherical form at the point where the impeller is located, thus reducing the clearance and leakage, especially with feathering blades in the Kaplan turbines. This "clearance cavitation" is dangerous because it can cause erosion on the guide wheel foot.



CHANGING THE ANGLE BETWEEN WATER FLOW AND BLADE SURFACE AT ENTRANCE GREATLY AFFECTS THE AMOUNT AND DISTRIBUTION OF SUCTION ON BACKS OF BLADES

For some types of turbines, the efficiency increases somewhat at the cavitation limit, explained by the reduction in blade friction when water breaks away from the blade just below the point and later follows the blade surface.

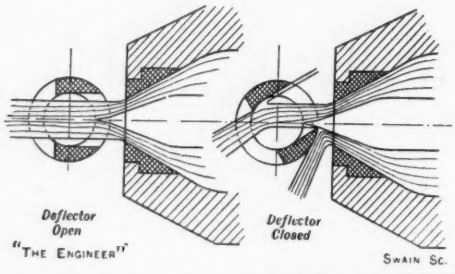
It is the purpose of the laboratory to determine by test the highest suction head that can be used for each type of blade at different speeds and total heads thus avoiding guesswork on the part of the plant designer as to the proper setting to use.

The Alabama Power Co., Birmingham, Ala., will begin preliminary work on its proposed hydroelectric power plant on the Coosa River, about 6 mi. from Wetumpka, Ala., and has organized a force of about 1,000 men for construction purposes. The plant has been designed as one of the largest hydroelectric power developments in the South; the power dam will be close to 90 ft. high. The station will be known as Lock 18 and is estimated to cost close to $15,000,000, with transmission system. It will require at least 24 mo. for completion. Initial operations will include the construction of a railroad line from Elmore to the power site for the transportation of machinery and materials; connection at Elmore will be made with the Louisville & Nashville Railroad.

Hydraulic Governor Balanced in All Positions

GOVERNING hydraulic turbines of the impulse type offers complications due to the usual high head and corresponding danger of water hammer when the jet is suddenly changed to meet load conditions. It is usual to control the jet by means of a needle valve and, in order to make the governor action instantaneous, use a deflector in front of the jet to act while the needle valve is operating over the necessary period of time.

Several deflectors have been developed, a unique design, shown on the sectional drawing, being described recently by the Engineer. The deflector is placed directly in front of the nozzle and the jet passes through it. When the deflector is rotated by the governor, the jet is split by the lower edge and deflected from the wheel in two separate streams. The reaction of the two streams acts on the deflector from opposite sides of the



JET IS SPLIT INTO TWO STREAMS BY DEFLECTOR

center line to balance one another, resulting in equilibrium in all positions.

In the specific installation described by them, the governor controls only the deflector while the needle valve is operated by hand to take care of prolonged periods of full or partial loads, as the requirements may demand. If necessary, the governor can be arranged to control both the deflector and needle valve by means of an oil-operated servo-motor and dashpot arrangement.

Associated Power Companies Offer to Lease Muscle Shoals

APPOINTED TO RECOMMEND for Congressional approval a lease of the Muscle Shoals properties, a joint committee of the Senate and House has favorably reported the offer of 13 public service power companies operating in Tennessee, Kentucky, Florida, Georgia, Alabama, Mississippi, Louisiana and Arkansas.

Transmission lines of most of these companies are interconnected in a super-power system in several southern states. The total installed horsepower capacity of the companies approximates 1,420,000 hp. with a generation in 1925 of about 3,024,000,000 kw-hr. The kilowatt-hour output of Muscle Shoals on a 70 per cent load factor will approximate 1,000,000,000 kw-hr. or almost one-third of the 1925 generation of the thirteen operating companies.

The offer is made by the Muscle Shoals Fertilizer Co. and the Muscle Shoals Power Distributing Co., organized by the Associated Power Companies. The Muscle Shoals Fertilizer Co., the stock of which is owned by the Muscle Shoals Power Distributing Co., proposes to lease the two nitrate plants and the Waco Quarry and operate plants for the production of fertilizer. It is to be provided with $20,000,000 capital as needed and will have preferred use up to the entire power output of the power plants, if needed, for an ultimate production of 40,000 t. of nitrogen for use in concentrated commercial fertilizer, mixed or unmixed, with or without filler, such as ammonium phosphate and other nitrogenous fertilizers.

Within six years the fertilizer company will provide plant capacity for 20,000 t. of nitrogen and necessary phosphoric acid plants. Fertilizer is to be sold at cost of production plus 8 per cent profit. Power will be supplied for fertilizer production at cost.

A farmers' board will be named by the Secretary of Agriculture representing farmers organizations, who must be real farmers. Two other members of the board will be a representative of the Department of Agriculture and a nominee of the fertilizer company.

The first unit for 10,000 t. of nitrogen and phosphoric acid plants necessary for making ammonium phosphate will be put in operation within three years.

Additional units of 10,000 t. capacity will be built for fertilizer production up to 40,000 t. of nitrogen, in response to market demand as authorized by the farmer board and the Secretary of Agriculture when, for two successive years, the demand has taken the output of the plants constructed. A modified Haber Process for synthetic ammonia will be used such as has been in successful commercial operation in the United States for several years.

Power will be sold to power distributing companies throughout several states to aid in meeting the power needs of the various sections. The total rental payments at Dam No. 2 for 50 years will approximate $137,000,000. Not to exceed $1,200,000 a year will be paid for additional power at Dam No. 2 (included in the above amount) as the result of storage and other headwater improvements. If Dam No. 3 is built by the Government, rental payments for a lease period ending with Dam No. 2 will approximate $75,000,000.

The Government is not required to expend further sums at Muscle Shoals, except for Dam No. 3, which is not contingent upon acceptance of the offer.

The Government has the right, at any time, to take over all or a portion of the fertilizer plants or the power plants for purposes of war, during which time the obligations of each company and rentals will be proportionately suspended.

TO ANYBODY interested in research in any field, the Bibliography on Research issued by the National Research Council, 29 W. 39th St., New York City, will be of value. It covers selected articles appearing in the technical press of this and other countries during 1923-4-5, arranged according to subjects of research, thus giving for any investigator a comprehensive view of what has been reported during the last three years. Details of specific researches are not included as the intent is to cover general articles showing trends and the importance of applied science in the industries.

New Conveyor Tests are Successful

RECENTLY DEVELOPED PNEUMATIC SYSTEM HANDLES COAL, ASH AND SEVERAL OTHER MATERIALS WITHOUT DUST OR DAMAGE

PNEUMATIC CONVEYORS have, in the past, been somewhat limited in their application due to dust, or to the inadvisability of bringing the material in contact with steam used in the system. Dust and structural reasons often keep the discharge tank from being placed indoors with the result that in cold weather moisture collecting from the condensed steam combines with water used for dust elimination to cause trouble from freezing. Furthermore, many materials cannot be handled by direct steam contact systems due either to destructive effects of the steam or to the formation of a sticky mixture which clings to the inner surface of the pipe.

Backed by many years experience in steam jet conveyor work as well as five months' intensive development and field tests, the Aro-Carrier is proclaimed by the manufacturers, the Conveyors Corp. of America, an entirely successful development in the conveyor field. Designed as a true pneumatic conveyor to handle any bulk material of a granular nature which may be readily fed into a pipe opening by gravity, dust has been eliminated and the exhauster element entirely separated from the material.

ANY TYPE EXHAUSTER MAY BE USED

Either a steam jet or rotary exhauster may be used to exhaust the operating head and give the necessary air velocity and volume to carry the material through the pipe. Referring to the figure, air and conveyed material enters the operating head through the pipe A, the heavier material falling on the gates in the accumulator zone while the air, separating, is discharged through the suction zone D. Carefully placed louvres in this zone separate the entrained dust and automatically returns it to the accumulator with the bulk of the material.

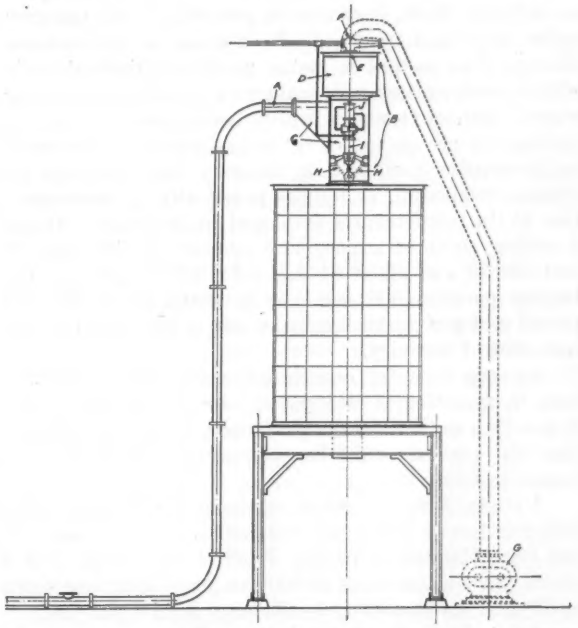
Although the feed to the accumulator is continuous, the discharge is intermittent caused by the operation of the gates H, which prevent air from being drawn through the discharge opening. Material collects in the chamber, or accumulator zone, until the weight on the gates is sufficient automatically to trip the hydraulic operating cylinders located on the side of the chamber. The cycle of opening the gates, discharging the material and restoring the accumulator head to its original sealed state consumes not to exceed 1¼ sec.

ADJUSTMENT PROVIDED TO REGULATE TRIPPING PERIOD

As the opening of the gates and discharge of the accumulated material depends entirely upon weight, an adjustment is provided by which the tripping period of the gates may be changed to answer better the needs of various materials. Standard sizes can be adjusted to trip at any weight up to 1000 lb. but special sizes can be furnished to meet specific requirements for greater amounts.

Pulverized fuel, stoker ash, grain, brewers' malt, granulated chemicals, coal and other materials have been successfully handled. Capacities as high as 23.6 t. of stoker ash per hour have been reported through a 5-in. suction line, although test results during a public demonstration were somewhat lower, due possibly, to the lower steam pressure available at the steam jet exhauster nozzle. During this demonstration weighed quantities of materials were conveyed through a horizontal distance of 34 ft. with a 16-ft. riser at rates given in the table.

Material	Density	Steam Pres.	Tons per hr.
Coal	47	100	17.5
Stoker Ash	37.5	102	11.1
Comb. Ash	36	94	10.0
Oats	32	100	16.5
Roofing Gravel	96	102	13.0



GENERAL ARRANGEMENT OF EQUIPMENT OVER A CAST IRON RECEIVING HOPPER

Steam consumption of evactor not to exceed 2400 lb. per hr. at 125-lb. per sq. in. pressure, about 1975 lb. per hr. at 100 lb.

LARGE ROCK TRAVELS 16 FT. PER SECOND

This was a 5-in. suction line installation with a multi-jet high efficiency steam jet exhauster. The coal was a mixture varying from dust to lumps the size of a baseball. Stoker ash was received direct from the boiler room, the larger clinkers being broken with a hammer so as to pass through the pipe opening, while the combustion ash was taken from a pile which had been placed outside the previous day. It was as coarse as fine sawdust and damp enough to stay moulded when pressed firmly in the hand. At the end of the test a 2-lb. rock as big as a man's two fists was sent through the 40 ft. of pipe in 2½ sec.

Absence of dust was a noticeable feature during the tests showing the effectiveness of the dust separating baffles in the operating head. Furthermore the material

as discharged from the hopper showed no change from the condition in which it was fed into the suction line. Separation of the coal dust from the air indicates that the conveyor will handle powdered material as well as lump coal.

Various materials may be handled through the same operating head by running suction branch lines and using multiple spouting below the discharge point.

The Diphenyl Oxide Boiler

BY FAR the most interesting event at the meeting held in conjunction with the Second Chemical Equipment and Process Engineering exposition held in Cleveland, Ohio, May 10 to 15, was the presentation of the paper by H. H. Dow, of the Dow Chemical Co., on the Diphenyl Oxide boiler for bi-fluid power plants.

This boiler, developed at the Dow Chemical Works at Midland, Mich., is similar in principle to the mercury boiler developed by W. L. R. Emmet, of the General Electric Co., in that it makes possible a thermal cycle with a much greater temperature range than when using water. Diphenyl oxide, which heretofore has had no commercial use except in the manufacture of perfumes, is inexpensive compared to mercury and, although an organic compound, undergoes practically no decomposition at the temperatures employed in the boiler. It has a boiling point at atmospheric pressure of 496 deg. F. and solidifies at about 81 deg. At 200 lb. pressure the boiling point is 800 deg. It is worth about 30c per pound and per unit volume the cost is less than two per cent that of mercury.

An experimental installation using this boiler has been in operation at Midland for about 2 yr. and, while it is only a small unit, the performance seems to indicate that the process could be successfully employed in a larger installation.

A study of the thermo-dynamics of the diphenyl oxide boiler indicates a Carnot cycle efficiency when expanding from 750 deg. to 70 deg. F. of 54.6 per cent. For a steam plant using steam at 500 deg. and expanding down to 70 deg. the Carnot cycle efficiency is 44.8 per cent.

Aside from the decided thermal advantages to be derived from the diphenyl oxide boiler plant, the particular boiler proposed by Mr. Dow possesses several other interesting points, chief of which is, perhaps, the two-stage combustion system used. The boiler consists of several water-tube elements in series, with a furnace for each of the first two elements. Half of the total amount of fuel used is introduced into the first furnace and the other half in the second furnace. The last element discharges the gases of combustion at about 900 deg. to a heat interchanger which reclaims most of this heat and returns it to the first furnace. It is due to the fact that the air entering the furnace is so highly preheated that two-stage combustion is necessary. If it were not used, the highly preheated air would create such a high furnace temperature that no refractories could withstand the heat.

The heat interchanger itself is novel. It consists of a group of cells containing scrap iron through which the gases of combustion and the incoming air pass successively. The entrance of the gases and the air to the cells is controlled by a pair of rotating valves which rotate once in seven minutes. It is highly effective and usually discharges the flue gases at a temperature within 100 deg. of the surrounding atmosphere.

So far as operation is concerned, the diphenyl oxide system should introduce no insurmountable difficulties. Like the mercury boiler at Hartford, it is connected direct to a turbine, the exhaust of which passes into a condenser-boiler, generating steam at about 650 deg. The weight of the diphenyl vapor is 9.4 times that of steam which should make possible the design of a turbine with a high efficiency.

While the boiler proposed by Mr. Dow utilizes two-stage combustion, in the experimental installation at Midland it is not used, due to the inability of the stoker to withstand a temperature of over 300 deg. for the incoming air. An exhaust or waste heat boiler is, therefore, interposed between the heat interchanger and the furnace which reduces the temperature of the air leaving the interchanger from 800 deg. to 300 deg. With a different type of stoker or with a system burning the fuel in suspension, it should be possible to introduce the 800 deg. air from the interchanger directly into the first furnace.

It may appear strange upon first thought that the gases of combustion should be permitted to leave the final element of the boiler at a temperature of 800 deg. and then to reclaim this heat for use in the furnace. When the problem is studied carefully, it will be obvious that this results in a much more efficient heat cycle than if the heat were absorbed in an economizer because, in introducing this heat into the furnace, it is added to the top of the temperature range. An economizer adds the heat at the lower part of the thermal cycle, that is, somewhere usually between 70 and 212 or more deg. F. The air preheater, on the other hand, by increasing the temperature of combustion adds the heat to the upper portion of the heat cycle resulting in a much greater Carnot cycle efficiency. This is a point which has often been neglected in comparing various thermal cycles. With an economizer, the heat has a Carnot cycle efficiency of perhaps 18 or 20 per cent but, if the heat is put in at, say, 600 deg. instead of between 70 to 300, it has an efficiency of perhaps 50 per cent.

The history of the diphenyl oxide boiler is interesting. Although it was developed at Midland by the Dow Chemical Co., the idea of using diphenyl oxide in a bi-fluid boiler belongs to Mr. Emmet. In his search for a suitable medium for a binary vapor system, Mr. Emmet investigated a large number of substances, among them diphenyl oxide, which he stated was unsuitable because it would decompose at a certain temperature. It was Mr. Emmet's statement that started the investigation at Midland, for at the time, they were manufacturing diphenyl oxide at Midland at a higher temperature than that at which Mr. Emmet said it would decompose. Apparently, Mr. Emmet's conclusions were due to his working with an impure example.

With his paper, Mr. Dow showed a number of interesting charts and tables indicating the properties of the diphenyl-oxide-water cycle which cannot be given here. A complete copy of the paper, however, will appear in an early issue of Power Plant Engineering.

IT TAKES ALL sorts of fools to make a world—including the kind that won't use safety devices, remarks E. J. Senne of the National Safety Council.

Oxy-Acetylene Welding in Refrigeration Work

By Charles H. Herter

AT A RECENT meeting of the National Association of Practical Refrigerating Engineers the importance of oxy-acetylene welding to many phases of refrigerating practice was convincingly shown by representatives of the Oxweld-Acetylene Co.

In addition to motion pictures illustrating the versatility of the oxweld process, there were several interesting papers and discussions. It was pointed out that if changes are to be made in existing atmospheric ammonia condensers, the oxy-acetylene blowpipe is unequaled by any other method. As ammonia fittings are quite expensive, and screwed joints are liable to leak, most refrigerating machine manufacturers have adopted welding as standard in shop practice.

In a paper entitled "What the Oxy-Acetylene Process Means to the Refrigerating Industry," J. W. Catalane discussed a few of the more important benefits, as follows:

Strength and tightness, it is probably agreed, are the two prime requisites for a good joint. Coupled joints have great difficulty in retaining those qualities even for a short time against the stresses and biting corrosives peculiar to refrigerating piping. Not only is there pressure to be overcome but a certain amount of vibration and unsteady pulsation especially near pumps and compressors. To this add the stresses due to temperature changes. At first standard pipe was used with screw coupled joints but these readily fractured. The cause for this was, of course, that in threading, 40 to 50 per cent of the pipe wall is cut through, leaving it weakened to that extent. The next step was the adoption of a heavier and more expensive pipe to satisfy the coupling. Here we have the first reason for the oxwelded joint. Using standard, unthreaded pipe, it makes the strongest and most pliable installation possible. A welded line is good as long as the pipe itself because such a line is a single long tube.

Freezing Tank Coils Welded

Recently a coupled ammonia installation of a new ice plant in Chicago went bad; leaks developed all over and despite the application of every known method of stopping them without dismantling the coils, it was impossible to make them tight. To dismantle the coils completely, remove all flanges, clean them and the pipe ends, reconnect and caulk with litharge would have taken the better part of a month and the company was anxious to begin plant operation with the busy season. Conversion by welding was suggested, adopted, and within five days every one of the 400 defective fittings had been removed with the oxy-acetylene cutting blowpipe and pipe sections welded in their places. Test proved the joints tight and no trouble has developed since.

Dismantling Made Easy

Dismantling, altering or rebuilding welded or coupled pipe is easy work with the oxy-acetylene process. A clean, narrow cut is made with the cutting blowpipe and any change in slope, direction or size welded in. Not only are the advantages of the process realized on straight pipe and coils but in the construction of headers, traps, elbows, manifolds, reducers, crosses, tees, and ells. Maintenance on such is reduced to a minimum, for when once in position no repairs ever need be made.

Compactness, another goal of refrigerating experts, is accomplished by welding. In condenser coils for example return bends are nested so compactly that no drip plates are needed between pipes. It is interesting to note that besides compactness, tests conducted at the laboratories of the University of Illinois proved that a 180-deg. return bend using welded joints produces 6 to 8 per cent less friction than a cast steel return bend.

Underground lines must meet different conditions of stress than plant piping. When a line is buried deep enough to avoid fluctuating weather conditions, the expense is sufficient to warrant installation of a line which will remain intact for years. And here again welding comes to the fore. Not long ago a large refrigerating plant in a mid-western cold storage center had occasion to lay long stretches of pipe lines which were for the purpose of supplying refrigeration to buildings along its route. These were made up of extra heavy pipe and, naturally enough, oxy-acetylene welded throughout for it was desirable that the cost of a joint, installed by the thousand, be reduced to a minimum. Oxwelded joints attain this feature. Not only does a weld prove its relative cheapness by endurance in the long run, but the first cost is less than any other joint.

Welding Replaces Soldering of Ice Cans

In the construction of other refrigerating equipment the oxy-acetylene process also plays a big part. Previous to oxwelding ice can seams they were riveted and soldered—an elaborate and unsatisfactory practice. The brine corrosion and ordinary rust soon attacked the unprotected part of the rivet exposed during stressing and rendered the can worthless. It is extremely difficult to crush an all-welded ice can; even when stressed to destruction of the sheet the welds remain tight.

Other equipment fabricated to great advantage by fashioning metal with the cutting and welding blowpipes include ammonia generators and receivers, floats of all kinds, brine tanks, conveyors, coil specialties, condensers, ice dumps and chutes, can hoists and brine agitator parts.

The ice manufacturer has a seasonal fluctuation of business more extreme than that of most industries. And when he is busy, he is very busy. It seems predestined by fate, for often when business is at its peak, when the plant is operating at high speed to fill the demands of a heat wave, something goes wrong. If it is metal it can be welded.

Repairs Made Quickly

A 16-ton casting—the base of an ice machine—broke in three places a short time ago. The casting was 27 ft. long, 16 ft. wide and too large to remove to the welding shop. It was stripped of attached parts, raised and blocked by fire bricks. The entire job including veeing the crack, preheating and welding was completed and the machine in operation again in three working days. In the field of repair we might also cite the example of an ammonia compressor which was so badly wrecked that it was apparently worth little more than scrap. The plant manager, however, was optimistic concerning the possibilities of the oxy-acetylene process and the welders were set to work. After machining the complete welds, and "cleaning up" the piston on a lathe to

exact diameter, the compressor was assembled, started running, and still is going after two years. The time saving of this operation was extremely valuable at that season. A cash saving of $910 was also noted. A new compressor would have cost $1100 whereas the cost of restoring the wrecked machine was only $190.

Castings Cut by Flame

The importance of the cutting blowpipe is never undervalued by the man who owns one. Its most popular use in scrapping has solved many a problem of how to get a large unused flywheel through a small door, or how to get a great obsolete machine base out of a building whose rafters are unequal to its weight. Besides its use in the fabrication of equipment the cutting blowpipe is used on repair jobs for removing light obstacles in the way of the main job, veeing cracks for welding, removing staybolts and frozen-on nuts.

Various other welding repair jobs are done on pump cylinders, pulley wheels and electrical equipment. Building up worn parts at points where abrasion is severest, is a common practice with the welding blowpipe. Such parts are turned on a lathe or otherwise machined to correct dimension.

Development of oxy-acetylene welding and cutting has evolved standard methods of operation. These have been worked out jointly by refrigerating and oxy-acetylene engineers. Methods of making the best and cheapest pipe joints, for instance, have been worked out and rules for design and cost sheet prepared. Bronze welding, a comparatively recent development, permits repairs on large or small castings (ammonia excepted) without preheating or removing attachments. In every field the benefits of cast iron cutting have been great.

Commercial Stocks of Anthracite and Bituminous Coal

INVENTORY of coal stocks as of April 1, 1926, shows 40,000,000 t. of bituminous coal in the hands of consumers, according to the Bureau of Mines, Department of Commerce. This is slightly lower than at a corresponding period last year, but about midway between the stock figures of June 1 and September 1, 1925. The trend since the beginning of the year has been gradually downward to more normal proportions. Consumption continues to be more than production which, during February and March, has ranged downward from 12,167,000 to 9,626,000 t. a week, indicating greater inroads upon stocks.

When comparing stocks of coal on the several stock-taking dates reported in the previous surveys of this series, full consideration must be given to the consumption rate during the period covered. At the rate prevailing during February and March this year, there was on April 1 a supply sufficient to last 26 days. This is 11 days less supply than in March a year ago, the nearest like date for which figures are available for comparison, but four days greater supply than on March 1, 1923. If no substitution for anthracite had been necessary, the supply on February 1 would have been sufficient for 31 days but at the actual rate of consumption, prevailing during January, the supply was enough for 28 days. As has been regularly mentioned in these reports, this average day's supply figure, while useful for comparison with figures for other stock report dates, is not indicative of the true situation in many localities and industries, for the individual supplies range from little or no coal on hand to very large reserves of fuel.

There were, in addition to the tonnage in consumers' hands on April 1, about 2,900,000 t. of coal on the Lake Superior and Lake Michigan docks; slightly less than 200,000 t. stored by the producers at the mines or at points between the mines and market; and approximately 1,000,000 t. loaded in cars but unbilled at mines. The first of these items is lower, as is normal at the end of the coal year, and the other two items higher, than on February 1.

With the resumption of anthracite operations in February, retail dealers' stocks of anthracite naturally have increased considerably since the preceding date of stock taking, February 1. Retail stocks of bituminous coal on April 1, while lower than at the time of the previous stock report, have not declined to any unusual or abnormally low level. Surplus stocks of by-product coke at merchant plants on April 1, despite the record-breaking production during the two-month period under discussion, were even below the record-breaking minimum of February 1, 1926, amounting to only 57,000 t. At the beginning of the anthracite suspension in September, by-product coke stocks were 832,000 t.

Department of Commerce Analyzes Stoker Sales

FOR THE MONTH of April, 1926, the Department of Commerce announces sales of mechanical stokers, as given in the accompanying table, compiled from reports of 12 establishments. Comparative statistics for the period from April, 1924, to April, 1926, are also included.

TABLE SHOWING STOKERS SOLD, HORSEPOWER AND KIND OF INSTALLATION

Year and Month	Establishments reporting (No.)	STOKERS SOLD No.	STOKERS SOLD Hp.	INSTALLED UNDER Fire-tube boilers No.	Fire-tube boilers hp.	Water-tube boilers No.	Water-tube boilers Hp.
1926							
April	12	145	70,055	22	4368	123	65,687
March (1)	12	132	52,312	31	3680	101	48,632
February	13	83	33,141	12	2065	71	31,076
January	13	72	36,913	10	1388	62	35,525
1925							
December	13	108	47,104	21	3895	87	43,209
November	13	76	33,461	8	1260	68	32,201
October	13	114	53,451	22	3864	92	49,587
September	13	119	38,155	34	7563	85	30,592
August	13	91	29,865	27	3880	64	25,985
July	13	147	58,719	30	5075	117	53,644
June	13	128	44,095	26	4625	102	39,470
May	13	122	55,588	23	3934	99	51,654
April	13	120	47,627	23	5893	97	41,734
March	13	131	71,099	17	2446	114	68,653
February	13	135	46,298	28	4905	107	41,393
January	13	57	27,871	4	870	53	27,001
1924							
December	13	91	31,732	18	1788	73	29,944
November	13	106	37,167	11	1675	95	35,492
October	13	104	58,565	7	1702	97	56,863
September	13	73	25,988	27	6646	46	19,342
August (2)	13	94	41,931	17	2486	77	39,445
July	15	115	37,759	14	1660	101	36,099
June	15	102	35,549	19	2724	83	32,825
May	15	64	34,447	3	550	61	33,897
April	15	89	47,939	15	1970	74	45,969

(1) One establishment discontinued the manufacture of mechanical stokers.

(2) Two establishments consolidated with other companies.

Application of Centrifugal Pump Chart Limited

IN THE April 1 issue, p. 438, the centrifugal pump theory in the article by Charles Fromm is correct, but many will question its usefulness. The concluding formula $H = K \frac{U^2}{2g}$ is correct but the difficulty lies in finding the value of K. The shut-off head can usually be determined within 10 per cent by that method. From that point on, not even a good guess can be made as to the remainder of the curve unless the general type of pump is known.

Some time ago I had occasion to buy a circulating pump for 6000 g.p.m. against 28 ft. head. Figure 1 shows curves for characteristics of three different pumps offered by three companies. The difference in

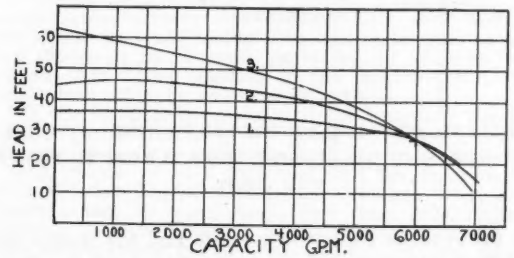


FIG. 1. THESE CURVES SHOW CHARACTERISTICS OF PUMPS OFFERED BY 3 DIFFERENT COMPANIES FOR THE SAME SERVICE

the shape of the curves is caused by the different vane angle. The flat curve is given by the pump with the more nearly radial vanes. From the shut-off head, the value of K changes at every point of the curve. It is true that a certain type of pump built by a manufacturer usually has the same general characteristic but this is of little value except for specific cases.

In the three cases given the product of KU^2 is the same for all three pumps at point A. As U^2 is a constant, the shape of the characteristics depends upon the variation of K. On curve 1 the change in K from the point of impending discharge to the operating condition is 28/37 = 76 per cent; on curve 2 it is 28/45 = 62 per cent; and on curve 3 it is 28/63 = 44 per cent. So you can see that if those three propellers had been measured and the heads calculated from the formula the results would not have equalled a good guess. Calculated by Mr. Fromm's method with an average value of K = 0.825, the operating heads would have been found to be 28.7 ft., 35 ft., and 49 ft. respectively for 1, 2 and 3.

Although a case might arise where an old pump is found without information or name plate data, nobody would proceed to cut down the impeller or go to the expense of changing the pump speed on the authority of formulas or charts. The only satisfactory method is to test the pump to find the characteristic and calculate the changes necessary. If a test cannot be carried out several pressure gage readings at various rates of discharge will indicate to an experienced man the changes

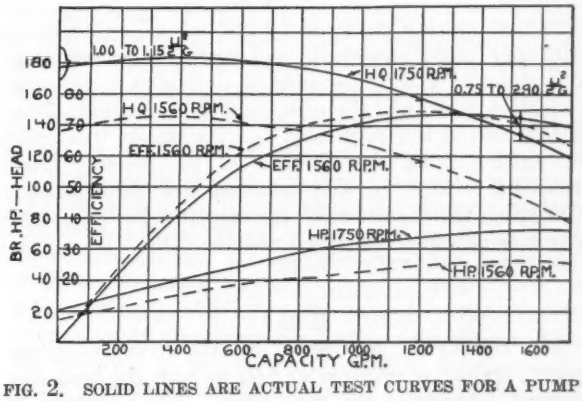


FIG. 2. SOLID LINES ARE ACTUAL TEST CURVES FOR A PUMP AT 1750 R.P.M. AND THE DOTTED LINES ARE CALCULATED FOR THE SAME PUMP AT 1560 R.P.M.

necessary to reach the desired conditions. With no data at all, one must simply speed up the pump until it pumps.

If a pump characteristic or even one set of conditions is known, the effect of changes in speed or impeller diameter can be calculated from the following relation which holds true at constant efficiency:

$$\frac{N_1}{N_2} = \frac{Q_1}{Q_2} = \frac{\sqrt{H_1}}{\sqrt{H_2}} = \frac{\sqrt[3]{\text{Br. hp.}_1}}{\sqrt[3]{\text{Br. hp.}_2}}$$

where N_1 and N_2 are respective speeds, r.p.m.; Q_1 and Q_2 are g.p.m. respectively; H_1 and H_2, head in feet for respective conditions; Br. $hp._1$ and Br. $hp._2$, brake horsepower for respective conditions.

In Fig. 2 the solid lines show actual test curves of a pump at 1750 r.p.m. The operating conditions are 1200 g.p.m. at 158 ft. with an efficiency of 73.5 per cent. If the operating conditions change, it may be advisable to change the speed or impeller of the pump. Suppose the head was reduced to 118 ft. and the same flow of 1200 g.p.m. desired. By reducing the speed to 1560 r.p.m. the head capacity curve would be changed to that shown by dotted lines.

The following table shows the calculations made in finding the new curves at the lower speed. The efficiency, head, and capacity at 1750 r.p.m. are taken from

the curve or test data and corresponding values of head and capacity are calculated by slide rule by decreasing the capacity directly as the speed, and the head as the square of the speed. The efficiency remains the same for all points and the horsepower can be calculated

TABLE OF DATA FOR CURVES OF FIG. 2

		1750		1560		
Point	Eff.	Head	Cap.	Head	Cap.	Br. Hp.
1	0	178	0	141	0	..
2	56	182	600	144	535	35
3	72	162	1115	128	995	44
4	73.5	141	1410	112	1260	48
5	70	116	1725	92	1540	51

using the cube of the speeds or more conveniently by using the head capacity figures just calculated:

$$\text{Br. hp.} = \frac{H\,Q}{3960\,\text{Eff.}}$$

After noticing the speed of 1750 r.p.m., an engineer with any pump experience will be fairly certain that the pump is a direct connected unit with a 60 cycle induction motor and the speed cannot be changed. This is true and in this particular case the change was made by cutting down the diameter of the impeller from 13.75 in. to 12.25 in. and installing new shroud rings. Changing the diameter of the impeller has the same effect as changing the speed and the ratio

$$\frac{1750}{1560} = \frac{13.75}{12.25} = 1.12.$$

In finding the new speed to suit given conditions some juggling is required at first as both the head and capacity change at the same time. It is necessary to make several trials to find the proper speed.

To be fair to Mr. Fromm, it should be stated that his formula applies to this particular impeller and calculated heads are indicated between limits on Fig. 2, K for the operating point of this pump is about 0.925.

Anybody who has studied Daugherty's or DeLaval's book on centrifugal pumps will agree that Mr. Fromm's article is strictly correct without further explanation, but it would seem to be misleading to the uninitiated.

Bronxville, N. Y. B. MARKER.

Available Draft Limits Combustion Rates

NO DOUBT others besides myself have been struck by the claims made by some operating engineers and manufacturers of grates, stokers and other combustion equipment as to the high rating at which they can operate boilers.

I am quite willing to believe, for instance, that hand-fired boilers burning anthracite coal with forced draft can operate considerably over rating provided there is an adequate stack, but there seems to be a tendency never to claim less than 200 per cent while some makers of natural draft stokers will talk about 200 per cent rating provided the stack is anything over 125 ft. high and sometimes less, quite ignoring the fact that the total draft of such a chimney apparently would not do more than take care of the resistance through the boiler and breeching at this rating and the resistance through the fuel bed presumably would have to be zero.

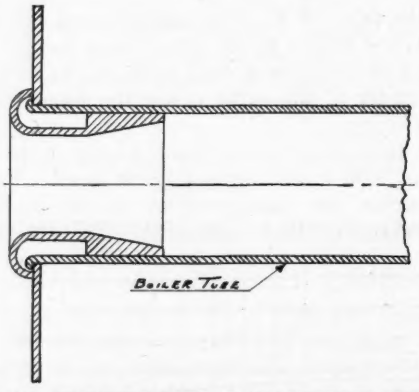
Often it is difficult to combat such statements by showing that they are theoretically impossible, and one always must bear in mind the fact that in some cases conditions may be more favorable than those generally assumed for the theoretical calculations.

I think that it would be of general interest if somebody could furnish reliable data based upon observation as to ratings actually obtained in practice, and especially as to cases where authentic ratings have been obtained in excess of those which theoretical considerations alone would indicate as being probable.

Newark, N. J. J. O. G. GIBBONS.

Cast-Iron Sleeve Protects Fire Tubes

IN THE accompanying figure is shown a device which serves as a protector for the tubes of a fire-tube boiler.



IN ENGLAND, FIRE-TUBE BOILERS ARE PROVIDED WITH CAST-IRON SLEEVES AT THE OPENING OF EACH TUBE TO PROTECT THE JOINT

This protector is made of cast iron and fits snugly into the tube but is not necessarily machined on the fitting surface.

Its use was suggested by a boiler inspector to prevent leaky tubes but he offered no explanation as to how it accomplishes its purpose. According to his statement, its use is quite common in England and especially in the British Navy.

I would be pleased to know whether a device of this kind is in common use in this country and whether any explanation is advanced for its preventing leaky tubes.

Green Bay, Wis. CHARLES J. VIRGIN.

Adopting the Metric System

ALTHOUGH personally not enthusiastic about the metric system, there is no question in my mind but that the United States will some day adopt it, if not in the near future. The handwriting is on the wall. Every country of any importance in the world has already adopted it—all but the United States and Great Britain. No doubt the transition period from our present standard to metric will cause much expense and inconvenience, but the sooner we jump in and have it over with, the better.

It is not commonly known that the famous James Watt, an English engineer and scientist, originated the

decimal system of measurement. I have always considered it of French or German origin myself, but that is not so. Nor is it well known that our present English system is of German origin. We therefore have the unique condition of the English speaking people clinging to a German system, which even the Germans themselves have dropped, and the balance of the world using an English system.

Probably the simplest way to remember the relation between all of the units in the two systems, is the following in approximate figures: Length—one yard plus 10 per cent=one meter; weight—two pounds plus 10 per cent=one kilogram; Volume—one quart plus 5 per cent=one litre.

Recently there was brought to my attention the following interesting paragraphs written by the works manager of a large American manufacturing concern that has already switched over to the metric system. Surely he should know what he is talking about:

"The great cost of the change to the metric system has been proved by the experience of those who have adopted it, to be overstated. My own experience in a large plant, covering a period of 15 yr., enables me to say, unequivocally, that the cost of the change in any machinery producing establishment will be more than paid for in the very first year of operation. The trouble is that many manufacturers have been persuaded to believe that in order to make the change, it would be necessary to throw away all drawings, patterns, jigs, fixtures, and small tools. Some even go so far as to say that it would be necessary to scrap machine tools. The real facts in the matter are that the size of nothing whatever need be changed. The sizes are merely called by another name or expressed in another unit.

"Furthermore, it should be borne in mind that most manufacturers already are offering tools and machinery with metric dials and metric sizes, and these must be made, even though it be in small quantities, in addition to the English sizes. The adoption of the metric system would obviate that difficulty and expense entirely.

"If the opinions expressed and the testimony furnished in regard to the metric system could be confined to people who have had actual experience with it, the problem would be very simple. I have just read that the railroads have testified before the Committee on Coinage, Weights and Measures that it would take more than $200,000,000 to make the necessary changes in the machinery of the railroads, if the metric system were adopted. As one who has operated a large machine shop for years under the metric system, I can say that none of the machinery would need to be changed, nor would there be any benefit whatever obtained by changing it. Let us once and for all recognize the fact that the statement often made that all patterns, jigs and machinery must be scrapped if we are to use the decimal system, is erroneous.

"One of my acquaintances, in speaking of a certain engineer, remarked, 'A man who can do a job is worth ten men who cannot'; and so I think that the testimony of persons who have actually made the change to the metric system and used it in shop work for years, is worth any amount of testimony of those who have merely personal opinions, but who have had no experience with the changing over from one system to the other."

Newark, N. J. W. F. SCHAPHORST.

Power Salesman Has Valuable Suggestions

AS A RULE, the engineer is not getting the returns in information and excellent advice from the salesman that he could get if he would accept him as the authoritative representative of companies who are doing a great deal for the engineer.

The salesman is trained in the application of the product he sells and, if allowed to do so, will be a valuable source of information, suggesting ways and means of reducing the cost of operation. Trade journals and the salesman are about the only connecting link between one engineer and others of the profession and, if the salesman is encouraged (made a friend), he will gladly pass on from one to the other valuable kinks and money-saving suggestions. He is constantly running across unusual situations which have been met in an efficient way and the engineer should make use of this opportunity to keep up to date. Also, we must consider that he has received special training by his company for the purpose of meeting the engineers' needs for his products and instructing the user in the application of the product so that the greatest returns possible will be secured.

I have found that, with few exceptions, the salesmen calling upon me are honest in their efforts to render me a service and, if their product is not adapted to my needs, they say so and tell me where I can secure the material needed. I also find that if a salesman does not have the information needed, he has back of him a company ready at all times to put its technicians and laboratories to work solving my problem. If I am going to progress with the others who appreciate this valuable service, I must receive the salesman not as a man who is trying to sell me something but one who is doing me a favor by so presenting his proposition that I can judge its value to my plant.

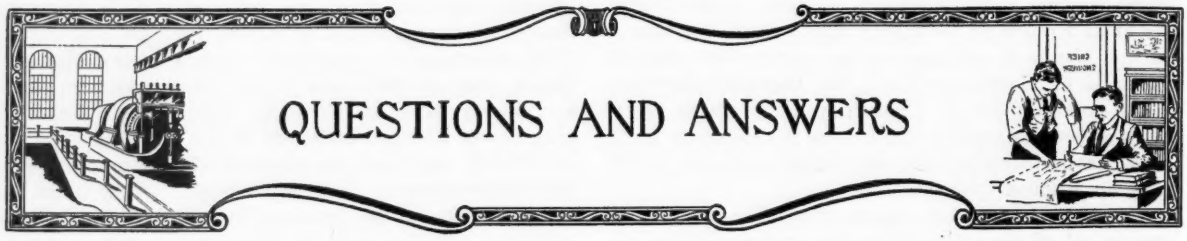
Trade magazines have a value all their own, not only the editorials, articles and discussions by readers, but their greatest value to the engineer is found in the advertisements. Reading them will keep one posted as to the materials available and the results possible with modern equipment. But to secure the greatest returns on the time spent reading, one should pay especial attention to the bulletins issued by the companies which give details of their various products and their application, and spend a stamp requesting any of particular interest. I much prefer them to engineering text books in many respects, as they are up-to-date and, what is more to the point, practical.

When the engineer finds that he can make a worthwhile saving by the installation of some advertised product, he should not rush to the office with an exaggerated general statement of what it will save, but he should secure all of the information possible on the subject and present it in a clear, concise manner, free from technicalities and in the language the superintendent knows; that is, a careful estimate of installation, operating and maintenance expenses, expected life, and possible savings.

Both the salesman and advertising sections of magazines have another thing usually lacking in the engineer and that is salesmanship and advertising or how to present a proposition from the prospect's viewpoint of the product.

Listen to the salesman's presentation of his proposition as he builds up curiosity, develops your need for the product, establishes confidence and value, selling to you himself first, then his company and their product. The engineer can learn much from him about selling and that is just what he needs to do, selling himself as an efficient department head. At present his selling and advertising methods are poor and the cause, in many cases, of the present low wage scale.

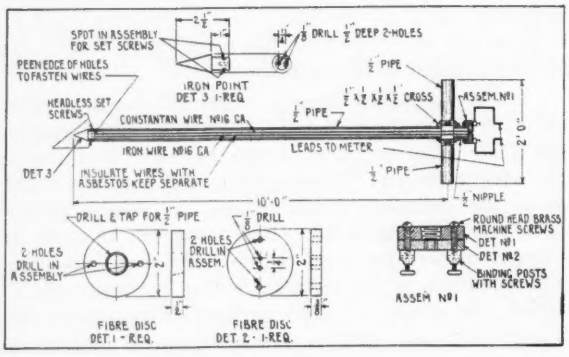
Vermillion, S. D. L. A. COWLES.



Thermocouple Used for Coal Storage Temperature

LOCATED near the plant, we have a coal storage pile of about 1500-t. capacity. From time to time we are troubled with overheating at certain points which quite often become incipient fires. Can you suggest a practical method for detecting the hot spots before any evidence is visible at the surface? A. R.

A. One of the best methods is periodically to probe the pile at various points and depths by means of specially designed thermocouples.



THIS SHOWS DETAILS OF THE CONSTRUCTION OF A BASE METAL THERMOCOUPLE FOR MEASURING THE TEMPERATURE OF A COAL PILE

In some cases operators have been known to sink pipes into the pile at different points and then, by means of chemical thermometers lowered through these pipes, have attempted to arrive at the temperature. Obviously this method is subject to considerable error and the thermometer does not come in direct contact with the coal but merely indicates the temperature of the air within the pipe. Besides this, before the thermometer can be raised to the top of the pipe, where it can be observed, the temperature indicated may have fallen appreciably.

One of the simplest and yet one of the most effective methods of obtaining coal pile temperatures is found by using a thermocouple similar to one shown in the accompanying figure.

Essential features of this thermocouple are shown by the detailed drawings. It has much the appearance of a long spear and consists primarily of a 10-ft. length of ½-in. pipe provided at one end with a spear-shaped point into which the positive and negative wires of the couple are fastened, and at the other end with a head for the binding posts as shown in assembly No. 1. By means of the cross-T near the head of the thermocouple, provision is made for 10 or 12-in. handles so that the pipe may be pushed into the pile to the desired depth.

Fires start from 4 to 6 ft. beneath the surface and if the temperature of the pile reaches 140 to 150 deg. F. and continues to rise, it is likely that within a short time, a destructive temperature will be reached. Coal at this temperature should be removed immediately.

Where the coal pile is as large or larger than the one mentioned in the inquiry, it probably will be better to employ two men for the temperature measurement. One man may be used to climb over the top of the pile and insert the thermocouple at various points, while one remains below to take readings with a portable potentiometer or galvanometer. The man handling the thermocouple should carry a thermometer for measuring the air temperature at the cold junction.

Figuring the Size of a Crankpin

PLEASE explain the method of figuring the proper size of crankpin for any given size of engine. C. M.

A. In a recent book called Principles of Machine Design, C. A. Norman states that in determining the size of a crankpin, it should be computed for bending, the bending moment being PL÷2, where L is the length of the pin and P is the maximum force on the rod. The bending stress may be assumed to be 7000 to 10,000 lb. per sq. in. The crankpin also should be computed for bearing pressure.

It is further stated that according to investigation by Lewis and Kessler, the pressure on pins of over-hung crank for high speed stationary engines is 900 to 1500 lb. per in. while for low speed engines it is 800 to 1300 lb. per sq. in. In order to secure proper heat dissipation, the friction work per square inch of pin bearing area must not exceed a certain value. The friction work is proportional to pv, where p is the pressure per square inch and v is the rubbing speed in feet per minute. The value of the product may vary in actual engines from 50,000 and less to as much as 200,000, dependent on speed of rotation, special cooling influences and other factors.

Bach gives the values for pv=C, listed in the following table:

Oil standard	55,000
For excellent cooling conditions and good attendance (comparatively short pins of large diameter, hence with large radiating bearing parts)	133,000
Exterior crankpins of locomotives	370,000
Journals of crank shaft, bronze bearings	22,000
Journals of crank shaft in babbited boxes, up to	59,000
Passenger car journals	118,000
Locomotive journals	220,000

The friction work of a journal in foot-pounds per minute is

$$\frac{3.1416\ PfN}{12}$$

where f is the coefficient of friction, P the total bearing load, d the journal diameter in inches, and N the r.p.m. Per square inch of projected bearing surface this becomes

$$\frac{3.1416\ PfN}{12 \times Ld} = pvf,$$

or

$$\frac{3.1416\ PN}{12\ L} = C$$

This relation does not contain the journal diameter d. Hence, it can be used for determining the necessary bearing length simply from the empirical value for C. After this length is determined, the bearing diameter may be made such as to give a reasonable bearing pressure. The ratio of the length L to the diameter d of the pin may be taken from 1 to 1.25, at times perhaps more.

As an example of a side crankpin problem we may assume a steam engine of 10 in. cylinder diameter runs at 150 r.p.m. and has a steam pressure of 125 lb. per sq. in. What should be the dimensions of the crankpin?

Assuming the maximum force on the connecting rod to be equal to the maximum force on the piston, we have for the maximum rod force

$$\frac{3.1416 \times 10^2 \times 125}{4} = 9820 \text{ lb.}$$

Assuming that $L/d = 1.1$, and that the bearing pressure is equal to 1000 lb. per sq. in. we obtain

$$1.1d^2 \times 1000 = 9820$$

$$d = 3 \text{ in.}$$

$$L = 3.3 = 3\tfrac{5}{16} \text{ in.}$$

Assuming the diameter of the pin in the boss to be 2¾ in., we find the bending stress

$$\frac{PL \times 32}{2 \times 3.1416\ d^3} = \frac{9820 \times 3.313 \times 32}{2 \times 3.1416 \times 2.75^3} = 7950 \text{ lb. per sq. in.}$$

That is, if anything, too low. The rubbing speed is

$$\frac{3.1416 \times 3 \times 150}{12} = 118 \text{ ft. per min.}$$

hence $pv = 118 \times 1000 = 118{,}000$, which seems permissible.

Maximum CO_2 Obtainable from Fuels

In the answer to the question, "What is the maximum amount of CO_2 that can be obtained with any fuel?" in the April 15 issue, it is stated that no higher percentage than 20.9 is obtained in actual practice; that this is due to the fact that the amount of oxygen in the air, by volume, is 20.9 per cent; and that for this reason, the scale of CO_2 meters is graduated up to 21 per cent only.

I wish to call attention to the fact that the statement "any fuel" should be modified since with certain gaseous fuels, flue gases are commonly obtained having as high as 25 per cent CO_2. I too was of the opinion that 20.9 per cent was the maximum, until I started analyzing the gases from blast furnace gas fired boilers found in all steel plants having blast furnaces. I had a portable Orsat that ran up to only 21 per cent in graduations, and I had to get a new outfit.

A blast furnace gas of the following composition, and it is not an extreme case, has its combustion calculated thus:

Gas	Percentage	Portion of cu. ft.	Cu. ft. O_2 required	Accompanying N_2 from air, cu. ft.
CO_2	15.7	0.157	.....	.....
CO	22.8	0.228	0.114	0.431
CH_4	0.0	.....	.....	.....
H_2	3.7	0.037	0.019	0.072
N_2	57.8	0.578	.....	.....
Total	100.0	1.000	0.133	0.503

For perfect combustion the resulting flue gas will be:

Products of Combustion, cu. ft.		
CO_2	H_2O	N_2
0.157	.....	.....
0.228	.....	0.431
.....	.....	.....
.....	0.019	0.072
.....	.....	0.578
Total 0.385	0.019	1.081

The total volume of gas resulting from the combustion of one cubic foot of blast furnace gas, measured under the same conditions of temperature and pressure would be 1.485 cu. ft. But as the water vapor in the flue gas condenses out in the analyzer, the actual volume of flue gas involved is 1.466 cu. ft.

Then the final analysis of the flue gas would be:

Flue Gas	Portion of Cu. Ft.	Per Cent of Total
CO_2	0.385	26.2
N_2	1.081	73.8
Total	1.466	100.0

From this, we see that the analyzer mentioned would be inadequate for blast furnace gas. Similarly, in using producer gas with high initial content of CO_2, a high percentage of CO_2 in the flue gas may result, but ordinarily it does not exceed 20 per cent.

In ordinary power plant work, such gases as these are not met with, but in most steel plants, they are quite common.

Pittsburgh, Pa. C. W. Stevens.

Editor's Note: Statement in April 15 issue refers to all solid or liquid fuels where there is no amount of CO_2 present in the fuel before combustion begins. It was stated that the maximum amount of CO_2 only could be 20.9 per cent with an all carbon fuel burned with no excess air.

Even with blast furnace gas, if it were possible to have no CO_2 present in the gas before combustion begins, the maximum CO_2 with no excess ordinarily would not be more than 17 to 18 per cent.

Replacement gaskets on the cylinder heads of air compressors should be made the same thickness as those furnished by the manufacturer, in order to insure proper clearance between the piston and cylinder head. Any good sheet asbestos packing is suitable, but rubber should be avoided as it will gradually soften from the effects of oil and the heat of compression.

EDITORIAL COMMENT

Benefits of High Pressures Now Applicable to Industrial Plants

Having demonstrated that high-pressure steam turbines can be designed and operated economically in large power plants, engineers are now turning attention to their application in industrial plants. Although many industries have recognized the need and value of high steam pressure, equipment for generating, transmitting and using steam of over 300 lb. pressure has been commercially available only in recent years. To design and construct boilers, piping, fittings and control equipment especially for one or even a dozen industrial plants would be an expense probably outweighing many times the economic advantages accruing from the use of the high pressure.

As a rule, small plants cannot afford to experiment with untried equipment, particularly main units of the plant, built from specially designed patterns. When, however, such equipment has proved successful in plants of other industries and can be manufactured in quantities, the initial cost comes within reach of more plants and it is then that its application to the problems at hand should be carefully considered.

High-pressure steam turbines have been quite thoroughly tried out in a number of large power plants of the country; manufacturers are now in position to furnish these prime movers from standard designs and patterns; performance guarantees are being made and met with remarkable accuracy. Under such conditions, industrial plants should consider carefully the advantages which high-pressure steam offers in their particular cases and those who are contemplating changes in their plants will be aided in their study by what Mr. Hodgkinson has to say on other pages of this issue.

Spring Is a Time of Preparation

For most business firms the fiscal year will soon end and it is high time for power engineers to begin planning for the coming year. Before the board of directors meets to appropriate funds for the various departments, the power plant engineer should be alive to the needs of his plant and make every effort to have his department recognized in the appropriations.

For most plants, the heating season is almost over, or at least reduced to a minimum and now is the time to think of next year's needs. Perhaps last winter's load showed that the stack was inadequate and smoked badly or perhaps the baffles allowed short circuiting of the gases. Don't delay action until next fall when all the boilers may be needed on short notice but decide on the most economical plan at once, present it to the proper authority and be prepared to back up your arguments with satisfactory figures.

If you present your ideas of improvement now, before annual appropriations are made, in most cases you will stand a much better chance of getting permanent improvements, than if you wait until winter when only make-shift repairs can be made.

In plants having a refrigerating load, the season is just beginning. If you are an engineer in charge of such a plant and feel that certain equipment is going to be needed this summer, now is the time to make known your wants.

That boiler which you operated all winter is by now probably full of scale. Provide yourself with a good tube cleaner and get ready for the next heating season. Look over your steam traps, regrind those leaky valves and provide new packing where needed.

A coat of paint, applied here and there, works wonders in a power plant; and polishing the brass and nickel fittings will make the place more cheerful and inviting.

Spring is a time of preparation. It's house-cleaning time. All nature puts on a new dress and prepares to look her best. Why shouldn't you do the same for your power plant?

Apprentice Systems and Industry

Many years ago the artisan looked upon his trade with pride and developed an effective apprentice system to insure its continued successful existence. Apprentices were picked with care and given a thorough, practical, all around training so that the young journeyman was capable of handling anything that might come up. A marine machinist could take an engine casting and follow it from the layout floor through to the completion of the trial trip.

As our educational systems spread and living conditions improved, pride of accomplishment became secondary to monetary considerations so the apprentice system, unchanged from the days of medieval guilds, failed to keep pace with the development and rapidly declined in importance. This change was hastened by improved machine methods requiring only unskilled operators and by wartime production where labor of any kind was at a premium.

Industry is now feeling the sting of the dying monster's tail while leading manufacturers with business-like thoroughness are losing no time in giving considerable attention to the development of a modern system. Working in conjunction with school authorities, they can direct the industrial training and be free from the educational administration details.

Co-operation between manufacturers is necessary so that the smaller shops may have the opportunity of giving their men a complete training with the proper division of work and study to use and maintain vocational schools to best advantage. For the first time, the power plant has received industrial consideration and is included on many of the programs.

Such training sources fill a want not met by the high

school or college. They will do much toward again building up the dignity of labor, increasing the pride of accomplishment and, most important, tend to stabilize industry. Men will be educated and intelligent but not of the type which considers its present occupation as a temporary, obnoxious step on the way to the president's desk.

Whether It's Frogs or Power Plants, Ask Uncle Sam

Not long ago the editor of a certain business magazine had occasion to obtain some information about frogs. So he turned to that never-failing source of information, the list of Government documents, and he found that the Government has issued a pamphlet entitled "Frogs, Their Natural History and Utilization." "We knew," he says whimsically, "that a government that could supply us with 'Adventures in the Life of a Fiddler Crab' or 'Conditions Governing Existence and Growth of Soft Clam' would not fail us on frogs."

Such bulletins as this serve to illustrate the tremendous scope of the work done by various departments of the Government, results of which are issued in pamphlet form and sold at nominal cost. We wonder how many power plant men are using to the fullest extent the material available in these bulletins on coal and coal burning, in particular, and on all phases of power plant work in general.

Much of the most important work in coal burning research has been done by the Bureau of Mines, employing men who are national figures in the engineering field. Other departments of the Government, such as the Navy Department and the Bureau of Standards, have also contributed valuable material. To take a recent example, some of the most authoritative information available on pulverized coal has been issued by Uncle Sam.

Lists of all this material can be obtained from the Superintendent of Public Documents. As a citizen of this republic, you are supporting these great organizations that are constantly gathering for your use information on every conceivable subject that you can never find in any encyclopedia or textbook. A frog, to be sure, is either a food luxury or a biological specimen, depending on conditions, and you may not want much information about him. But coal and the proper utilization of it are foundations of power plant operation. Since you are paying Uncle Sam to collect vast quantities of information about it, why not at least have some of that information in your files? You never can tell when it will help you burn coal more economically.

The Function of History

When we studied history in the lower grades at school, we could see little more to it than a collection of names and dates; we were always extremely puzzled, on a balmy spring afternoon when the only thing worth while in the whole world was a plunge in the old swimmin' hole, as to why we had to study history instead. It was not until we were somewhat older that we learned that the real value of history is as a guide to what we may expect in the future.

In and of itself, history, whether of individuals, power plants or nations, may be interesting but is of no value. It is only when, by a study of history we get some idea of where we are headed, that it becomes important. And in the power plant, a study of records from this viewpoint, with an eye toward foreseeing trouble, providing for needed additional capacity and preventing repetition of past mistakes, will be of inestimable value to every engineer. There can be no resting on the oars in power plant work. What you have done and what you are doing now are of passing interest unless they help you to get a glimpse of what you will be called on to do tomorrow and of how you are going to do it. Read your plant history with the eye of a prophet.

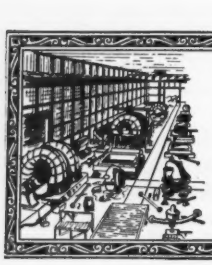
Will 1926 Be a Year of Mergers?

Of late it has been said that 1926 is to be a period of industrial mergers or combinations of producing companies. In a sense this recognition of existing trends is accurate and timely. From another standpoint, such a statement is entirely inaccurate and about 10 yr. behind the times. Since 1900, manufacturing concerns have been merging and corporations have steadily and progressively been forming larger single units. It is shown, for instance, by the United States Census Bureau, that during the 15 yr. between 1904 and 1919 manufacturing corporations increased 80 per cent while organizations not incorporated increased but 20 per cent. In the same period, employe personnel of corporations increased 105 per cent while the working personnel of non-incorporated establishments decreased 25 per cent.

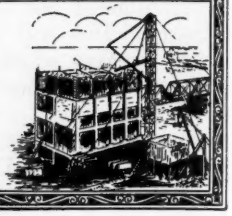
In the year 1919, over 30 per cent of all manufacturing enterprises in this country were incorporated. This plus 30 per cent employed 86 per cent of all wage earners engaged in manufacturing and produced 88 per cent of the total manufactured output of the country. Today the percentage of incorporated firms stands at 41. The recent acceleration is due to the fact that, under the spur of excessively keen competition and with the heritage of war-stimulated capacities, which are still with us, directors of manufacturing companies are seeking means for reducing operating expenses and overhead costs—and are finding it in mergers or co-operative combinations.

During the 15 years cited, industrial mechanical power, per workingman employed, increased from 2.5 hp. to 3.44 hp. And while that statistical fact would probably fail to inspire anyone to pen the Battle Hymn of the Republic or lend itself to an enthusiastic college yell, yet it remains that because of it, every American workingman is 33 per cent better off today than he was in 1910.

Properly controlled, large industrial organizations increase the use of mechanical power. This increased use of power cuts production costs, thereby decreasing selling prices, at the same time increasing earning power. Augmented earning power and decreased costs enlarge the margin between income and outgo. This enlarged margin creates the desire for fine clothes, fur coats, radio, automobiles, phonographs, bath-rooms, electric refrigerators, automatic gas ranges, and baker's bread. Thus are standards of living raised and contributions made to happiness and contentment.



POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS



N. E. L. A. Convention Opens With Thousands in Attendance

AS THIS issue goes to press, Young's million dollar pier at Atlantic City, N. J., is a place of great activity, for it is the scene of the 49th Annual Convention of the National Electric Light Association. From the preliminary reports on registration it appears that the figure of eight thousand, which was the predicted attendance of the meeting, was well estimated.

After a continual downpour of rain the entire preceding day, the opening day of the convention was gloriously fair, but that is only what one would expect. An organization which regulates the electricity supply of the nation and whose primary purpose is the generation and distribution of bottled sunshine should have no difficulty in controlling the activities of the weather man during the time of its convention.

The N. E. L. A. has much to be proud of this year. Over a million and a half new customers were added during the year and the Association now represents over a million customer-owners scattered throughout America. It was brought out that, in 1925, as much electricity was produced from 0.9 lb. of coal as was produced in 1920 from 3 lb.

At the session of the Hydraulic Power Committee it was shown that the 23 new hydro-electric plants placed in operation during the year added over two billion kilowatt-hours of energy to the 20 billion already produced from hydro sources.

From steam plants a larger volume than ever was produced, so that the ratio between hydro and steam plants was not disturbed. The total amount of power produced by both steam and hydro sources amounted to over 65 billion kilowatt-hours.

In interconnection, rapid strides have been made during the year and, as was pointed out by E. J. Fowler, only 25 per cent of the electric light and power users now obtain current from isolated systems.

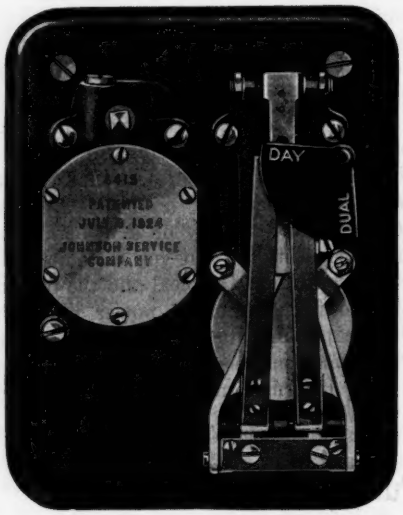
In his opening address, J. E. Davidson, president of the N. E. L. A., pointed out that electric motors are doing as much work every day as could be accomplished by 170 million men or four times the number of people in this country engaged in gainful occupation. Every worker, stated Mr. Davidson, has an average of over 4 hp. at his command, 75 per cent of the power in industry being electrical.

An important feature of the convention is the exhibit of electrical equipment on the million dollar pier. This is not only the largest ever held but also the most comprehensive. In the booths of the 174 firms represented is to be found every conceivable kind of electrical equipment; everything from an electric toaster or a washing machine to a machine for making concrete conduit. Not only are those firms making purely electrical equipment represented, but also manufacturers of steam plant apparatus used in the production of electricity.

At the sixth general session, held on May 21, R. F. Pack, vice president and general manager since 1916 of Northern States Power Co., Minneapolis, Minn., was elected president of the N. E. L. A. for the ensuing year. Mr. Pack was born in 1874 on the Isle of Wight, entered the employ of the Toronto Electric Light Co., Toronto, Can., in 1891, rising from office boy to general manager, and in 1912 became general manager of the Minneapolis General Electric Co., now a division of Northern States Power Co.

Dual Thermostat Gives Close Temperature Control

MOST HEATING AND VENTILATING plants for all classes of buildings, are designed and equipped with apparatus to keep all rooms at a predetermined temperature, near 70 deg., during the coldest weather,



DUAL THERMOSTAT FOR KEEPING UNUSED ROOMS AT TEMPERATURES BELOW NORMAL

night and day. For a long time engineers have wished that some method could be used to keep at a lower temperature, say 40 or 50 deg., those rooms which were not in use for certain parts of the day, restoring the normal conditions when the rooms were to be used. For a given building the saving that would thus be possible is self-evident.

This desire for variation in temperature control has led the Johnson Service Co., Milwaukee, Wisc., to develop the Dual Thermostat, shown in the illustration. The device is equipped with two bi-metal thermostatic elements. Change from normal or day to low or night temperatures is accomplished by a push button switch. This operates to lower momentarily the pressure in the air piping to 7 lb., restoring it to 15 lb. soon after. This changes the control so that the low temperature element takes charge. Each thermostat is equipped with a concealed key dial for setting the instrument. In large buildings the control can be made from a central point. No change in the air piping system of the building need be made to replace the standard Johnson single thermostat and only a slight change in the thermostat connection is necessary.

Flywheel Type of Alternator

THE IDEAL ELECTRIC & Manufacturing Co. of Mansfield, Ohio, which recently brought out a new line of motors called the "Flywheel Type," has now designed an engine type alternator on the same principle. This type of alternator construction creates a self-contained power unit, being an integral part of the engine, occupying considerably less space than the conventional design since it does away entirely with any generator foundation and erecting.

With the same rotor weight, the flywheel effect of the flywheel type alternator is claimed by the manufacturers to be nearly twice that of the present day design. If extra heavy flywheel effect is desired, the rotor construction has a double rim section as shown in Fig. 2.

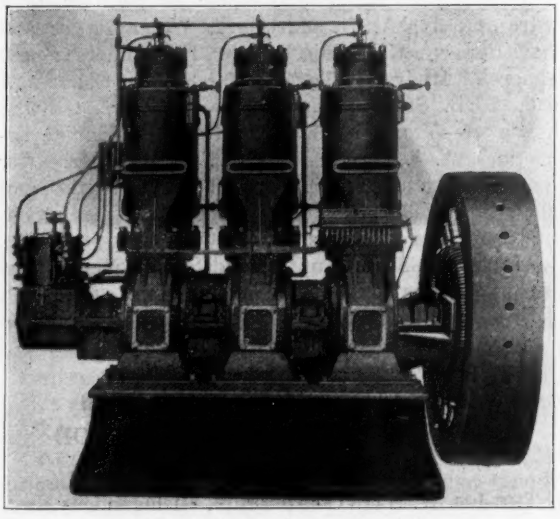


FIG. 1. ENGINE TYPE ALTERNATOR ATTACHED TO OIL ENGINE

This type of alternator adapts itself admirably to the "overhung" type without auxiliary flywheel and the problem of incorporating the necessary flywheel effect in the alternator rotor has merely become a question of bearing limitations. The air gap is always correct and uniform and will stay so during the life of the machine. An exciter or any auxiliary machine may conveniently be belted to the flywheel rotor, thus saving an auxiliary pulley.

Simple Device Protects Conduit Threads

EVERY ELECTRICAL CONTRACTOR and maintenance engineer has encountered the annoyance of chasing choked or damaged threads on conduit and pipe, in order to make them fit the unions and fittings with which they are to be used. To avoid this, it has hitherto been customary for the pipe manufacturer to supply a union on each length shipped, but since it is impractical to protect both ends in this manner on account of the expense, the difficulty is not entirely removed. Moreover, if the union is a tight fit it causes delay when removing it on the job—and if it is loose it is apt to shake off during shipment.

To solve this problem the Wedge Thread Protector Co., of Cleveland, Ohio, has developed the Wedge Thread Protector, which consists of a metal cap slightly tapered

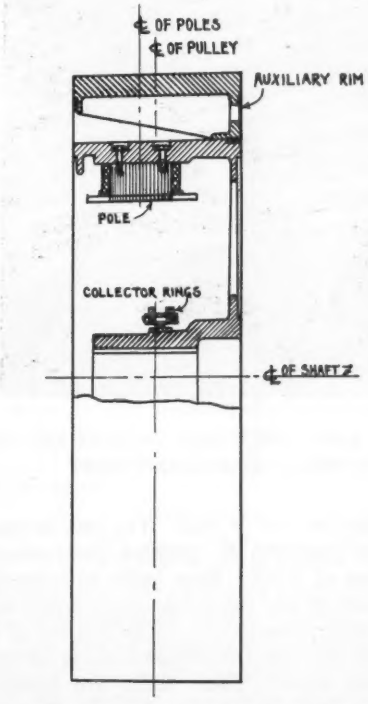


FIG. 2. DIAGRAM SHOWING DOUBLE RIM SECTION DESIGNED TO GIVE GREATER FLYWHEEL EFFECT

and having a shoulder to protect the first thread and a depression running all around the inner end so formed that it cannot be shaken loose. A paper cushion, which comes separately, is placed over the conduit end, and over this the metal cap is driven, either by a blow of the open hand or with a mallet. The protector, as described, is placed on the ends of the conduit by the manufacturer as soon as the threads are cut, thus protecting the threads during the subsequent enameling process and during shipment.

Although easily applied, the Protector cannot come off during transit but may be removed in a moment when desired by giving it a half turn with a Stillson wrench. Conduit thus protected can be stacked vertically, thus saving stockroom space for manufacturer, jobber and contractor in turn. The cheapness of these protectors permits their being thrown away after they have served their purpose.

Expansion Joint Provided in Beco Baffle Wall

TO PROVIDE for flexibility in a plastic refractory baffle wall, a continuous strip of corrugated sheet metal in each diagonal tube alley to separate the refractory material into layers, as shown in the illustration, is provided in the Beco baffle wall. This corrugated joint is designed to give a perfect sliding fit. The tubes are completely mortared into the plastic layers but the design is such that they can easily be removed or replaced

THIS SHOWS HOW BAFFLE WALL IS INSTALLED WITH CORRUGATED EXPANSION JOINT

without injury to tube or wall. The wall is designed to be perfectly gas-tight, to prevent short-circuiting of gases and loss of draft. Beco baffle walls are designed for installation at any desired angle in either horizontal or vertical water tube boilers. The method of supporting the baffle wall on the bridge wall is shown in the accompanying view. These walls are manufactured and installed by Boiler Engineering Co., Newark, N. J.

Power Specialty Co. Acquires Aero Pulverizer Co.

ANNOUNCEMENT HAS JUST BEEN MADE that Power Specialty Co., New York City, has acquired the Aero Pulverizer Co., manufacturers of the Aero unit pulverizer, and will contract either for a complete steam generating installation or for all the equipment necessary with the exception of the boiler, which may be supplied independently by the owner. In either case, the company will make guarantees of performance and assume the entire responsibility for results secured.

Such installations will consist of a unit comprising any boiler that the purchaser may favor, combined with a complete water-cooled furnace of Foster design, Aero unit coal pulverizers, Foster radiant heat or combination type superheaters, Foster economizers of the contra-flow type and Foster air heaters.

A.S.M.E. Announces Program for San Francisco Meeting

FOR THE SPRING MEETING of the American Society of Mechanical Engineers, to be held in San Francisco from June 28 to July 1, 1926, the following program has been announced:

MONDAY, JUNE 28

Morning—Council Meeting; Conference of Local Sections Delegates; Meeting Nominating Committee. Afternoon—Excursion to Muir Woods and Alternate Excursions; Shopping Trips for Ladies. Evening—Reception and Dance.

TUESDAY, JUNE 29

Morning—Meeting Nominating Committee; Simultaneous Sessions. Petroleum—Fluid Flow in Pipes of Annular Cross-Section, D. H. Atherton; Mechanical Engineering in Cracking, Heating and Cooling of Oil, B. N. Broido; The Termination of Charcoal Tests, F. L. Kallam. Industrial Training and Education—The Growth of University Extension Training of the Non-College Type for the Industries of the West, John L. Kerchen; Education and Training of Apprentices on the Pacific Coast, Paul Eliel.

Afternoon—Steamer Trip on San Francisco Bay; Ladies' Bridge Party.

WEDNESDAY, JUNE 30

Morning—Meeting Nominating Committee; Simultaneous Sessions. Fuels and Railroad—Combined Oil- and Gas-Burning Furnaces for Power-Plant Use, J. Grady Rollow; Fuel Oil for Railways, J. C. Martin, Jr.; The Development of the "Caterpillar" Tractor and Its Application to Industry, Pliny E. Holt. Hydraulics—Aspects of Steam Power in Relation to a Hydro Supply, A. H. Markwart; Water Power and Steam Power in California Utilities, H. A. Barre; Speed Changes of Hydraulic Turbines for Sudden Changes of Load, E. B. Strowger and S. Logan Kerr. Oil and Gas Power—Transmission of Power on Oil-Engine Locomotives, A. I. Lipetz; Oil Engines as a Drive for Pipe-Line Pumps, F. Thilenius; Uniform Methods of Calculating the Periodic Displacement and Oscillations in Synchronous Machines, C. W. Cutler.

Afternoon—Auto Tour Around San Francisco; Excursions; Ladies' Tea at Fairmount Hotel.

Evening—Banquet.

THURSDAY, JULY 1

Morning—Excursions.

The Jos. W. Hays Corporation Changes Name

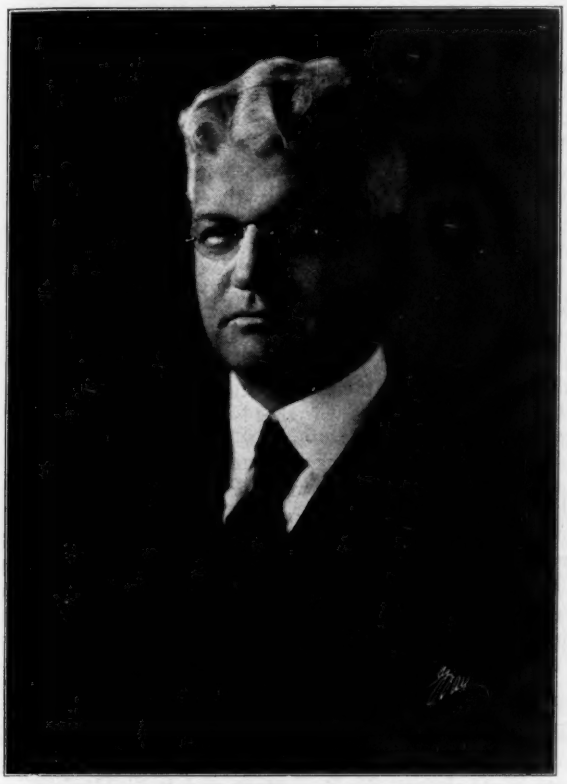
THE JOS. W. HAYS CORPORATION, Michigan City, Ind., announces a slight change in name to "The Hays Corporation." Jos. W. Hays, who founded the business in 1907, has disposed of his entire holdings in the company in order that he may devote all of his time to his practice as a consulting engineer. Philip T. Sprague, who has been closely associated with this business for a number of years as vice president and general manager, has been elected president.

Headquarters of Mr. Hays' consulting organization will be in Tulsa, Okla., where he has been located since last June. The headquarters of The Hays Corporation will remain in Michigan City.

Death of R. Sanford Riley Surprise to Many

ROBERT Sanford Riley, Worcester, Mass., president of the Riley Stoker Corp., died at his local residence, May 7, aged 51 years. Although Mr. Riley's death came as a shock to his acquaintances he had been ill for several months, suffering from anemia and heart failure. He was the inventor of the Riley underfeed stoker, used in power stations in all parts of the world.

Mr. Riley was born at Hamilton, Ont., but spent his boyhood days in Winnipeg. In 1896 he was graduated



as mechanical engineer with highest honors from Worcester Polytechnic Institute. Following, he engaged with locomotive and shipbuilding interests and later entered the United States Navy, serving as chief engineer of naval auxiliary vessels through the Boxer campaign in China and was connected with the Atlantic Station from 1900 to 1903.

At the age of 29 he became assistant to the chief engineer of the New York Ship Building Co. at Camden, N. J. Three years later he became manager of the American Ship Windlass Co. at Providence, R. I., developing many designs for marine equipment. It was here that Mr. Riley entered the stoker business by taking the Taylor stoker, as left by the death of the inventor, and developing it into a successful commercial device.

In 1911 Mr. Riley sold his interests in the American Ship Windlass Co. and organized the firm now known as the Riley Stoker Corporation, becoming its president. In 1917 his firm acquired the Murphy Iron Works and in 1922 the Underfeed Stoker Co. of America., both of Detroit, Mich. At this time his firm took over the business of the A. W. Cash Co. of Decatur, Ill., operating it as a subsidiary. In 1924 Mr. Riley's company also purchased the United Machine and Mfg. Co. of Canton, Ohio, makers of the Harrington stoker.

During the World War Mr. Riley served as chief of the Performance Division of the Emergency Fleet Corporation.

He was a member of the American Society of Mechanical Engineers, and the Society of Naval Architects and Marine Engineers. In 1925 he was president of the Stoker Mfrs. Assoc. Mr. Riley also belonged to a number of civic and social clubs.

He is survived by his wife and five children.

Carl Hering Dies Suddenly

ON MONDAY, MAY 10, CARL HERING, consulting engineer, Philadelphia, died suddenly at the Hahnemann Hospital in that city, where he was being treated for what was thought to be a slight affection of the heart. He was 66 yr. of age.

Dr. Hering, born in Philadelphia, graduated from the University of Pennsylvania in 1880 in mechanical engineering. In 1882, while teaching at the university he began the study of electrical engineering and in 1884 studied the subject at Darmstadt, Germany. In 1886 he began practice in Philadelphia as a consulting engineer.

Dr. Hering's work in electrochemistry began with storage battery research, but his best known discovery is that of the "pinch effect." His work in calculating and tabulating conversion factors was of great value and he also made original and thorough analyses of electromagnetic induction and light phenomena.

He was one of the founders of the American Electrochemical Society; past president, A. I. E. E. and A. E. S., and a member of many other engineering and scientific societies.

News Notes

FROM MONDAY, JUNE 21, TO FRIDAY, JUNE 25, next, the 29th annual meeting of the American Society for Testing Materials will be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Various sub-committees will report on the research work now being conducted by the society and papers by many prominent engineers will be delivered. Sessions of the meeting will be devoted to discussion of wrought and cast iron, steel, refractories, corrosion and fatigue of metals, cement and concrete, and other subjects.

COMBUSTION ENGINEERING CORP., New York, is installing two Combustion steam generators at the plant of the National Enameling Co., Granite City, Ill.

THE AMERICAN ENGINEERING CO., of Philadelphia, Pa., announces the appointment of H. Kempner as sales manager of its "Lo-Hed" electric hoist division. Mr. Kempner has been in charge of sales promotion work for the company for the past three years.

ERIE CITY IRON WORKS, ERIE, PA., announces that it has just opened an office in Cincinnati, O., in charge of Henry C. Hill. For 25 yr. Mr. Hill has been associated with his father, John W. Hill, hydraulic and sanitary engineer, in the design and construction of

municipal engineering projects and in special investigations for private corporations. Among the varied projects they supervised, the largest was the general improvement of the Philadelphia Water Works.

HENRY EGGELHOF, DALLAS, TEX., was recently appointed exclusive representative for the eastern half of Texas by the Uehling Instrument Co., of Paterson, N. J.

DEARBORN CHEMICAL CO. of Chicago announces that E. M. Mitchum has been transferred to the south Atlantic division, where he will have the management of the territory, with headquarters at Atlanta, Ga.

RILEY STOKER CORP., Worcester, Mass., announces that the name of its unit pulverizer, formerly known as the Atritor, will henceforth be the Riley Atrita, the latter name having been recently copyrighted.

THE WESTERN MAINE POWER CO., Limerick, Me., operating in York, Oxford and Cumberland Counties, has been acquired by the New England Public Service Co., Augusta, Me., Walter G. Wyman, president.

FRED G. RUMBALL, formerly branch manager of the Kansas City branch of the Timken Roller Bearing Service & Sales Co., has been made sales engineer, automotive division, of the Timken Roller Bearing Co., with headquarters at Cleveland.

THE BONNEY FORGE & TOOL WORKS, Allentown, Pa., has recently enlarged its sales organization by the addition of Ronald Wixson, who will cover the southeast coast states, and I. K. Fox, who will cover the southwestern territory.

J. F. MALONE, formerly connected with the Scranton Electric Co., Scranton, Pa., has been appointed commercial manager of the East Liverpool, Ohio, district of the Ohio Power Co., succeeding E. L. Happold, transferred a few months ago to another district.

WALTER P. SCHWABE, president and general manager of the Northern Connecticut Power Co., Thompsonville, Conn., has been elected president of the New England Division of the National Electric Light Association.

EDWIN M. HERR, president of the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., has been nominated for re-election as a member of the Yale Corporation, Yale University, New Haven, Conn., during the commencement exercises in June. He will act for a 6-yr. period. Mr. Herr is a graduate of the Sheffield Scientific School, class of '84.

FRED H. DANIELS, general manager of the Riley Stoker Corp. of Worcester, Mass., has been elected president to fill the vacancy resulting from the death of R. Sanford Riley. Aldus C. Higgins, vice-president, has been elected chairman of the board of directors and James W. Armour, engineering manager, has been elected a member of the board of directors. William Pestell, R. T. Riley and S. A. Armstrong continue as vice-presidents, David K. Beach as secretary and treasurer and George N. Jeppson, Charles L. Allen and Henry S. Pickands as directors.

Since the organization of the corporation in 1911, Mr. Daniels has been closely associated with Mr. Riley in the conduct of the company's affairs, having served as secretary, general manager and vice-president. He is a graduate of the Sheffield Scientific School of Yale University and of the Massachusetts Institute of Technology. The same policies will be continued as under Mr. Riley's leadership.

DAVID M. DILLON, president of the D. M. Dillon Steam Boiler Works, Fitchburg, Mass., and one of the founders and directors of several prominent New England industries, died on April 27 in the 84th year of his age.

In 1874 Mr. Dillon designed and constructed the first steam boiler of steel, which was exhibited at the Mechanics Fair in Boston. Although he was widely criticized at the time for substituting steel for iron, he was later praised for his foresight and inventive skill. Besides his own company, which from small beginnings grew to be one of the largest industries of its kind in New England, Mr. Dillon organized or was connected with many other important companies such as the Fitchburg Co-operative Bank, the Grant Yarn Works, the Parkhill Mills, Fitchburg Yarn Co., and many others.

CHARLES GEISSLER, a splicer in the employ of the United Electric Light & Power Co., New York, has received the Insull medal for the saving of the life of an associate workman through the prone pressure method of resuscitation. It was presented at a meeting of the Metropolitan Section of the National Electric Light Association, May 7.

J. McA. DUNCAN, district manager at Pittsburgh, Pa., for the Westinghouse Electric & Mfg. Co., for the past 14 yr., has been promoted to assistant general sales manager of the company with headquarters at East Pittsburgh. W. R. Marshall, heretofore branch manager at Buffalo, N. Y., succeeded Mr. Duncan at Pittsburgh, effective May 1.

THE CUTTER ELECTRICAL & MANUFACTURING CO. of Philadelphia has removed its New York office from 1170 Broadway to 12 East 41st St. The new telephones are Murray Hill 8145 and 8146. New York representatives are W. C. Jessup, M. B. Cutting and R. C. Heyl.

VACANCY is to be filled in the position of chief engineer in the U. S. Veterans' Hospital, Maywood, Ill., No. 76, at $3000 a year, and a list prepared for filling future vacancies requiring similar qualifications at the same or higher or lower salaries. Duties are the operation, maintenance and repair of a large heating, lighting and power plant with auxiliary machinery and equipment.

Any citizen of the United States may enter the examination which will be weighted as 50 per cent on practical engineering questions and 50 per cent on training and experience. Six years' experience in such work as described must be shown, 2 yr. in responsible charge. Each completed year of a high school course will be accepted as not more than 6 mos. experience. Applicants must be between 20 and 50 yr. of age but age limit, up to retirement age, is waived for applicants entitled to preference because of military or naval service.

Applications for the examination, which should be in June 14, should be made on forms 2374 and 2351

to be obtained from the secretary, Seventh Civil Service Dist., Chicago, Ill. Medical certificate and photograph taken within 2 yr. and signed by the applicant must be sent with the application.

Classified employes who have served 15 yr. and reached the retirement age of 65 are entitled to retirement with an annuity. To provide for this, a deduction is made of 2½ per cent of the monthly salary but this will be returned with 4 per cent interest in case of leaving the service before retirement.

J. J. P. MacKenzie, formerly with the investigation Bureau of the Mechanical Engineers Department of Brooklyn Edison Co., has joined the Engineering Products Division of Walworth Co., as assistant engineer.

William W. Bodine has been elected general manager of the United Gas Improvement Co., Philadelphia, Pa., in addition to his occupancy of office of vice-president. He has heretofore acted as assistant general manager. He is the son of Samuel T. Bodine, president.

Col. Claude Sweezy, Elkton, Md., has been appointed director of public safety at the Conowingo, Md., hydroelectric power development of the Philadelphia Electric Co., Philadelphia, Pa., and affiliated organizations. He will act in such capacity over about 3500 workmen who will be employed on the project for the next 3 yr.

Timken Roller Bearing Service & Sales Co. announces that T. F. Rose, formerly of the Chicago branch, has been appointed manager of the Cincinnati branch, and H. C. Sauer, formerly at Cleveland, has been made branch manager at Detroit. The branch office at Baltimore was closed on May 1. Service requirements in this territory will be supplied through the Richmond, Pittsburgh and Philadelphia branches.

Books and Catalogs

How to Buy and Use Fuel Oil. By Stephen O. Andros, Chicago, Ill.; 127 pages 5 by 7½ in. Boards; price $2.00.

This book has been written to give the man who uses fuel oil an insight into what he should buy and how he should use it. But it is a distinctive treatment as it is free from technicalities and is breezy and entertaining reading. Nevertheless, the information is there and the engineer, plant owner or purchasing agent who reads it carefully will get a good idea of the how and why of buying fuel oil on a reasonable basis and using it efficiently. We commend the book to readers and the method of presentation to technical men who write for the non-technical public.

Draft and Capacity of Chimneys. By J. S. Mingle. Size, 5½ by 8 in.; cloth; 329 pages with 9 pages of index; 74 tables and 18 charts. Published, New York; price, $3.50.

The author has combined the information on chimney design and operation in such a way that the book may well serve as a text for engineering students and designers.

The following statement by the author in his preface is of interest:

"In developing the theory of draft and capacity the two have been disassociated entirely, that is, it has been assumed that the height of the chimney is dependent only on the draft requirements and the diameter only on the capacity requirements, although each has a secondary influence on the other." In keeping with this, he has developed equations which consider all of these factors.

In all cases, practical problems are presented for consideration and their solution offered in suitable steps both by formulas and charts.

Heat Treatment and Applications of Nickel and Nickel-Chromium Steels is treated in bulletin No. 3 on Nickel Steel applications, issued by the International Nickel Co., 67 Wall St., New York. It treats of the physical properties of nickel, the effects of nickel when added to steel as an alloy, various heat treatments and their purpose, and for what uses various nickel-steel alloys are suited. Like data are given for chromium and for nickel-chromium-steel alloys. The bulletin is substantially a reprint of an article written for the handbook of the American Society for Steel Treating by Thomas H. Wickenden. Other bulletins are No. 1, the Society of Automatic Engineers Standard Specifications for Steels; and No. 2 on Physical and Mechanical Properties of Nickel Steels. Any of these bulletins as well as a binder for holding them can be obtained by any one interested by addressing the International Nickel Co., 67 Wall St., New York, and giving the writer's title and the name of the company with which he is employed.

The "Mechanical World" Electrical Pocket Book, 1926; 400 pages, 4 by 6 in., cloth; Manchester, England; price, 1/6 net.

Like its predecessors, this is a valuable little book, full of information on all phases of electrical engineering and sufficiently up-to-date to be useful in many ways to the electrical man. Many new features are included, among which may be mentioned the section of joining conductors. In this section a variety of methods is described for making joints in electrical conductors. Another section gives particulars of magnetic chucks and magnetic clutches. A lengthy section on industrial application of electro-chemistry furnishes information on the latest advances in electro-deposition of metals and of various electrolytic and analogous processes. At the end of the volume a number of tables giving mathematical relations are included.

Facts and Principles of Stoker and Powdered Coal Firing, by Joseph G. Worker, is the title of an interesting booklet issued by American Engineering Co., Philadelphia, Pa. Mr. Worker's article was first presented before the Canadian Pulp & Paper Assn., Montreal, Quebec, on January 27, 1926. It contains many data on the burning of coal in both industrial and public utility power plants, together with operating costs and many charts and diagrams of performance.

Rules for the installation and maintenance of electrical equipment in generating stations and substations are given in a new publication of the Bureau of Standards of the Commerce Department. These rules cover the general protective features of the station, as well as specific sections dealing with grounding, rotating equipment, storage batteries, transformers, conductors,

fuses, switches, switchboards, and lightning arresters. The new publication, known as Handbook 6, forms a part of the fourth or 1925 edition of the National Electric Safety Code. Other parts of the revised code will be issued as separate handbooks as soon as they can be prepared. Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 10 cents each.

GORTON & LIDGERWOOD CO., New York City, has just issued Catalog No. 92, describing Gorton heating equipment.

SMALL TURBO-GENERATOR SETS in sizes from ½ kw. to 10 kw. are described in bulletin No. 5 recently issued by Standard Turbine Corp., Scio, N. Y.

REFRACTORY CEMENTS as manufactured by the Norton Co., Worcester, Mass., are described in a booklet which has recently been published.

QUIGLEY FURNACE SPECIALTIES CO., INC., in a 12-page booklet describes the Quigley Refractory Gun, together with some of the uses to which it may be put in applying refractory material to furnace walls.

BUNDY STEAM TRAP CO. has just issued its 1926 catalog illustrating and describing the various traps manufactured by this company and calling attention to the specific advantages of these devices.

WATTS REGULATOR CO., Lawrence, Mass., is distributing some useful engineering data in chart form covering the flow of steam through pipes and showing the capacities of reducing valves.

A READY REFERENCE TABLE OF RAMTITE REQUIREMENTS has just been issued by The S. Obermayer Co., Chicago. A sliding scale, when set opposite the dimensions of a given wall, by means of a key number, gives the number of pounds of Ramtite required to build the wall to those dimensions.

DE LAVAL STEAM TURBINE CO., Trenton, N. J., has recently issued a 20-page leaflet dealing with the selection and application of centrifugal pumps to mining. The leaflet also contains instructions for the design of piping and the calculation of friction head power required.

SPRAY COOLING, issued by Yarnall-Waring Co., Philadelphia, Pa., is the title of an attractive booklet on spray cooling methods. The Yarway Type B involute spray nozzle with conical orifices and special fittings for spray cooling pond installations is described, and photographs are shown of many installations using this equipment.

GOULDS PUMPS as applied to a wide variety of pumping services are illustrated and described in a recent bulletin issued by Goulds Pumps, Inc., Seneca Falls, N. Y. In addition to the common use of these pumps for boiler feed, general water supply, and so on, they have found applications in handling many types of liquids such as fuel oil, and lubricating oil; for handling drainage; for use in dairies and in many other interesting ways.

A 24-PAGE illustrated publication, known as circular 1670-A, has just been issued by the Westinghouse Electric and Manufacturing Co., describing static condensers for power factor correction. One part is devoted to a discussion of power factor, its correction and the selective equipment; another part describes LD static condensers; the third part is devoted to low-voltage static condensers, describing the construction assembly and application.

BROWN RESISTANCE THERMOMETERS are described in Catalog 92 issued by The Brown Instrument Co., Philadelphia, Pa. These thermometers are designed for temperature measurements as high as 1000 deg. F. Details of the instrument are shown, both in the indicating and recording types, together with photographs of installations.

PENNSYLVANIA PUMP & COMPRESSOR CO. has just issued bulletin No. 127, describing direct connected synchronous motor-driven air compressors and bulletin No. 207, describing Class OMS Multi-Stage Centrifugal Pumps. The latter are of the single suction opposed impeller type and several detail drawings and photographs of their construction are shown in the catalog.

AMERICAN ENGINEERING STANDARDS COMMITTEE Tentative American Standards for Steel Pipe Flanges and Flange Fittings are discussed in detail in bulletin No. 6A, issued by Walworth Co., of Boston, Mass. Diagrams of fittings and tables of dimensions for pressures of 250, 400, 600 and 900 lb. at 750 deg. F. are given in tentative form, and it is stated that the development of flanges and flange fittings for 1350 lb. is under way.

THE LABOR SAVER for March, 1926, published by Stephens-Adamson Mfg. Co. of Aurora, Ill., contains an interesting article on the S-A Live Roll Grizzly, designed to be non-clogging. This is followed by an article on Mechanical Painting, describing and illustrating the painting of metal parts on a continuous quantity basis. The issue also contains an article on the S-A Traveling Scale Car.

TRUCKS FOR PUBLIC UTILITIES is the title of an interesting and well-illustrated 70-page catalog, recently issued by Graham Brothers of Detroit. Beginning with an article by Floyd W. Parsons on the Motor Truck in the Utility Field, the catalog goes on to describe the various types of trucks and their uses by the public utility and concludes with descriptions and photographs of various details of construction.

FOSTER WATER BACKS are described in detail in bulletin 261 recently issued by Power Specialty Co., New York. These water backs consist of water tubes forming a water-cooled furnace wall and supporting cast-iron blocks shrunk on the tubes to form a smooth furnace wall and conduct the furnace heat to the water in the tubes. Details and applications of these water backs are shown in the bulletin.

"SOME DEVELOPMENTS IN THE ELECTRICAL INDUSTRY DURING 1925," by John Liston, has been issued as a 62-page publication (GEA 385) by the General Electric Co., Schenectady, N. Y. The review covers each phase of electrical application and its outstanding developments during the past year. It is divided into numerous sections, contains 103 illustrations and an index.

"STEAM ECONOMY" is the title of an attractive catalog just issued by the Republic Flow Meters Co. of Chicago, Ill. This publication, designated at catalog S-33, describes and illustrates in a very interesting manner the various flow meters, pyrometers, draft instruments, CO_2 recorders and coal meters which are manufactured by this company.